GONIOTOMY IN THE TREATMENT OF CONGENITAL GLAUCOMA*

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Purpose of Paper

The results obtained from goniotomy in the treatment of 16 eyes with congenital glaucoma are reported. The outcome in these eyes, although the number is small, is comparable to that reported by Barkan (1942[1] and 1948[2]). All of the patients discussed in this paper have been followed for 1½ to 3 years following operation.

Historical

The treatment of congenital glaucoma has been discouraging in the past. Response to miotics is rare. The multiplicity of operations used in various clinics speaks for their inadequacy. Anderson,[3] in his monograph, pointed out that congenital glaucoma is one of the chief causes of blindness in children. He quoted surveys from several different countries which showed that 2.4% to 13.5% of children admitted to schools for the blind had lost their eyesight because of congenital glaucoma. He concluded his monograph by dwelling upon the poor outlook for patients with congenital glaucoma and stated that there was little hope of preserving vision sufficient for earning a livelihood.

The excellent results from goniotomy reported by Barkan afforded a marked contrast. Incision of the angle of the anterior chamber for the treatment of congenital glaucoma was first reported by De Vincentiis in 1893.[4] Anderson[5] states that several Italian and French ophthalmic surgeons have

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used the operation since that time in the treatment of congenital glaucoma. Some good results were apparently obtained but the operation has never become popular nor widely used.

Barkan used it on 17 eyes and first reported his results in 1942.[1] The tension was normalized in 16 of 17 eyes and visual function was maintained in 14. Of the 3 blind eyes, vision had been lost in 2 before surgery was instituted. In only 1 case, therefore, did operation fail to normalize the tension in time to save vision. In 1948,[2] Barkan added the results obtained on 76 eyes having congenital glaucoma. In 66 of these the tension was normalized and vision maintained. All of the children had been followed from 1 to 10 years. He concluded that, if done early, the operation gave excellent results. He therefore made a plea for early diagnosis and prompt surgery.

The results obtained in the treatment of congenital glaucoma at the Hospital of the University of Pennsylvania over a period of years had been highly disheartening. Because of these discouraging results and in view of Barkan's reports, we decided to try goniotomy, using it first in June, 1946, upon 2 eyes nearly blind from the disease (Case 1, H. W. B., and Case 2, A. O. K.). The tension was not controlled but, since the operation seemed relatively safe, we used it for more normal eyes.

TECHNIQUE

Operation was done under ether anesthesia. A Barkan knife (V. Mueller) was used without aid of the goniotomy lens. We attempted to use the lens in 2 eyes but it was cumbersome and contact with the cornea was difficult to maintain. The goniotomy knife was swept along ⅓ to ½ the circumference of the operated eye, as much as could be reached at each operation. Miotics were used postoperatively in some eyes but seemed to have no effect upon the outcome. Postoperative gonioscopy demonstrated scattered peripheral anterior synechiae along the incised portion of the angle of a

few eyes. More recently, therefore, we have filled the anterior chamber with air following goniotomy, employing the method outlined by Chandler (1949).[6] An oblique incision is made with a knife needle in the lower temporal portion of the cornea, through which air can be introduced with a fine needle, the tip of which not only enters the tract but goes through into the anterior chamber. All of our patients have been re-examined at intervals varying from 6 weeks to 3 months during the first year after surgery and then at least every 6 months. All tensions have been recorded under general anesthesia.

Case Reports

Case 1.—H. W. B., a 21-month-old white male, was admitted to the Eye Clinic of the Hospital of the University of Pennsylvania on June 6, 1946. His pediatrician had first noticed that his eyes appeared abnormally large when he was 6 months of age and referred him to an ophthalmologist for care. From that time until he was 21 months of age, a 15-month period, 7 paracenteses were performed on his right eye, the last in March, 1946, and 3 on the left, the last in February, 1946. The parents believed that his vision was poor in his right eye but that he could see well with his left. There was no family history of similar illness. He was a full-term child. His mother had had no illnesses during her pregnancy. The child had always been healthy. His development was normal except for his eyes.

General physical examination was negative. No other congenital anomalies were found. A Kahn test was negative.

Examination of Eyes:

Visual Acuity: Followed objects with left eye only.

External Examination: His lids were normal. Both palpebral fissures were somewhat widened. The corneas were definitely enlarged, the right more than the left. Both corneas were clear to the naked eye. The anterior chambers were deep. His eyes were white. The right pupil reacted sluggishly to direct light, the left normally.

Ophthalmoscopic Examination: O.D.: The media were clear except for lines in Descemet's membrane. The optic nerve was pale and deeply cupped. The retinal vessels were normal. The macula

was healthy. O.S.: Similar to the right eye, but the optic nerve head was normal.

Ocular Tension: O.D.: 33 mm. Hg., O.S.: 38 mm. Hg. (7.5 weight—Schiötz).

Gonioscopic Examination: Translucent embryonic tissue could be seen in the angle of the anterior chamber of each eye, apparently displacing the iris toward the angle wall.

Impression: Congenital glaucoma, bilateral. Defective vision of right eye due to optic atrophy.

Subsequent Clinical Course: The child was admitted to the Hospital of the University of Pennsylvania for treatment. Because of Barkan's remarkable results with goniotomy, we elected to carry

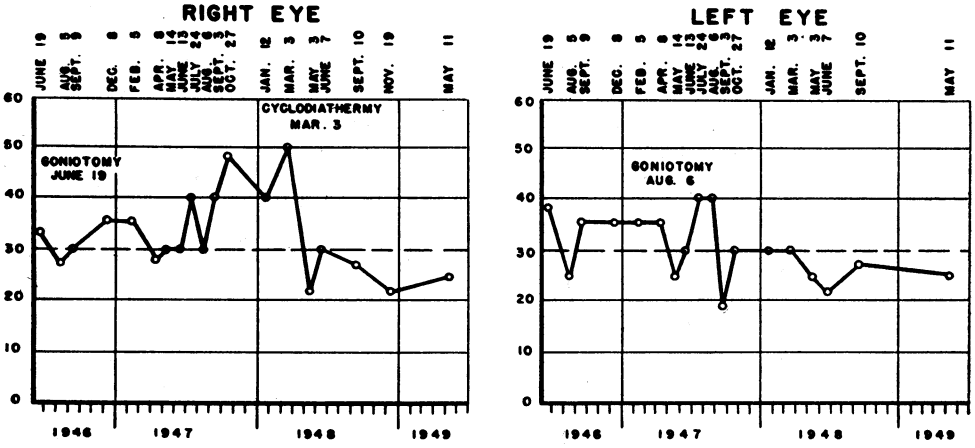

Fig. 1.

out this procedure on his right eye. Having had no experience with the procedure, we chose to do it upon this eye which was his poorer one, having only questionable vision. Goniotomy was therefore performed under ether anesthesia on June 19, 1946, without mishap. The eye showed little reaction. He was discharged from the hospital 2 days later to be observed subsequently in the outpatient department. The next ocular tension recorded was on August 5, 1946, when it was 27 mm. Hg. in the operated eye and 25 mm. Hg. in the left. Tension measurements were made at regular intervals of about 2 months during the next year (Figure 1). The ocular tension in the operated eye varied during that time from 27 to 40 mm. Hg. The tension of the left eye was somewhat lower until July and

August, 1947, when it was recorded at 40 mm. Hg. on 2 successive occasions. The cornea was increasingly hazy.

By this time, we had obtained apparently excellent results from goniotomy in several other patients with congenital glaucoma. We therefore recommended this procedure for his left eye and the operation was performed on August 6, 1947. Slight bleeding into the anterior chamber occurred but this absorbed promptly and convalescence was uneventful. From that time, the tension of the left eye has remained normal. The tension in the right eye, however, gradually rose, until in March, 1948, it was 50 mm. Hg. In an attempt to save the eye, a cyclodiathermy was performed on March 3, 1948, following which the tension has been stabilized at 22 to 30 mm. Hg. Both corneas are at present clear (Figure 2).

Results of Goniotomy: Right eye: (a) Goniotomy failed (probably due to the advanced state of the disease); (b) cyclodiathermy subsequently normalized the ocular tension. Left eye: Tension controlled by goniotomy.

CASE 2.—A. O. K., a 12-year-old white boy, was first admitted to the Eye Clinic of the Hospital of the University of Pennsylvania on May 20, 1946, because of poor vision in his left eye. This had first been observed 4 months previously during a routine examination of his eyes by the school doctor. He also had had some discomfort in the eye. His right eye had always seemed normal. No history of prior ocular difficulty could be obtained. He had had measles at 5 years of age and mumps at 7 years. No family history of ocular disease could be elicited. General physical examination was negative.

Examination of Eyes:

Visual Acuity: O.D.: 6/9, O.S.: hand movements.

External Examination: The eyelids were normal. His left palpebral fissure was slightly wider than the right and the left eyeball was somewhat more prominent than the right. Both corneas were slightly large, the left (14 mm.) larger than the right (13 mm.). To the naked eye they appeared clear. Ocular rotations were full. The conjunctiva and sclera appeared healthy. The pupils were round and regular, but the left (5 mm.) was larger than the right (4 mm.). Both reacted promptly to convergence. The right reacted promptly to direct light but poorly to indirect. The left reacted in the opposite manner, characteristic of damage to the left optic nerve.

Slit-lamp Examination: The corneas were clear except for ruptures of Descemet's membrane in each eye.

Ophthalmoscopic Examination: O.D.: The disc was normal in color and outline. The physiologic cup was normal in size and depth. The retinal vessels were normal. The macula was healthy. No lesions could be seen. O.S.: The findings were similar to the right except that the disc was very pale in color. A large glaucoma cup was present which extended to the disc margin. The vessels dropped sharply over the edge. Arterial pulsation was seen at the edge of the cup.

Ocular Tension: O.D.: 22 mm. Hg. (5.5 weight), O.S.: 35 mm. Hg. (7.5 weight).

Visual Fields: O.D.: The peripheral field was full to a 1/330 white test object and the central field was full to a 1/1,000 white test object. The blindspot was normal. No scotoma could be elicited. O.S.: Only a residual temporal field to light remained.

Impression: (1) Glaucoma, congenital; spontaneous cure O.D., (2) glaucoma, congenital, with optic atrophy O.S.

Subsequent Clinical Course: Pilocarpine 1% and eserine ½% were prescribed 4 times daily for the left eye, but this failed to reduce the tension, which continued between 36 and 42 mm. Hg. during the following week. DFP (di-isopropyl-fluorophosphate) 0.1% once daily likewise failed, although extreme miosis resulted.

He was therefore admitted to the hospital where a goniotomy was performed on his left eye on June 21, 1946. A considerable hyphemia occurred which absorbed promptly. His tension at the time of discharge from the hospital was 22 mm. Hg. in the operated eye. The tension of the eye was never over 22 mm. Hg.

Following his discharge from the hospital, the tension in the left eye remained normal for only a short time. On August 5, it was found to be 35 mm. Hg. and subsequently has never been below 40 mm. Hg. and has been as high as 65 mm. Hg. The goniotomy was judged a complete failure. The tension in the right eye has fluctuated between 17 and 22 mm. Hg., apparently representing a spontaneous recovery from congenital glaucoma.

Results of Goniotomy: Right eye: spontaneous cure. Left eye: goniotomy failed (probably due to advanced state of the disease).

CASE 3.—T. B., a 9½-month-old white boy, was admitted to the Ophthalmology Clinic, Hospital of the University of Pennsylvania, on March 19, 1946. His eyes had been large since birth and had always been extremely sensitive to light. He was seen by an ophthalmologist when only a few days old and pilocarpine was pre-

scribed. His eyes continued to become larger, however, and the sensitivity to light increased. His parents believed that his vision was very defective.

His delivery had been normal at full term. He had had no illnesses. His development was normal. His mother had been healthy throughout her pregnancy. There was no family history of eye disease. General physical examination was negative. A Kahn test was negative.

Examination of Eyes:

Visual Acuity: He followed a light with each eye.

External Examination: The eyelids were normal. Both corneas were greatly enlarged, measuring 14 mm. in diameter. The anterior chambers were deep. Each cornea was diffusely cloudy. Iridodenesis was seen in each eye. His pupils reacted to light. The conjunctiva was slightly injected. The sclera had a somewhat bluish appearance.

Slit-lamp Examination: Ruptures of Descemet's membrane were present in each eye.

Gonioscopic Examination: The angles could not be seen because of corneal haze.

Ophthalmoscopic Examination: Fundus view was also prevented by corneal opacity.

Ocular Tension: O.D.: 48 mm. Hg., O.S.: 56 mm. Hg. (7.5 weight).

Impression: Congenital glaucoma, bilateral.

Subsequent Clinical Course: He was admitted to the Hospital of the University of Pennsylvania on March 19, 1946, for further treatment. At that time, we were not as yet doing goniotomies, so bilateral Elliot trephine operations were done. The right eye was operated on March 25, 1946, and the left eye on March 29. The procedure was uneventful in the right, although the limbal tissue was found to be extremely thin. However, vitreous presented in the trephine opening following the iridectomy on the left eye. This eye developed a persistent iridocyclitis, and the cornea became opaque. He was discharged from the hospital 2 weeks later. A filtering bleb failed to develop in either eye. The tension was only temporarily lowered. He was subsequently followed in the outpatient department where his tension was found to rise gradually, until in July that of the right eye was 52 mm. Hg. (7.5 weight) and the left, 40 mm. Hg. (Figure 3). The cornea of the left eye had become permanently opaque. He was readmitted to the hospital on July 19, 1946, because of the elevated tension and a goniotomy was done on the right eye. A rather severe hyphemia complicated the operation

but this absorbed during the next 3 weeks. He was again followed in the outpatient department but the tension again gradually rose to 48 mm. Hg. by December 16, 1946. Another goniotomy was done on the right eye which was again accompanied by a hyphemia that absorbed slowly. The tension was again lowered for only a short time, after which it again rose, this time to 60 mm. Hg. We felt that his eye was probably too degenerative to be treated by goniotomy and resorted in desperation to a cyclodialysis, which was done on April 25. Severe anterior chamber hemorrhage ensued. The eye was by now so badly damaged by the glaucoma and previous surgery that the hemorrhage persisted for 2 months. When absorp-

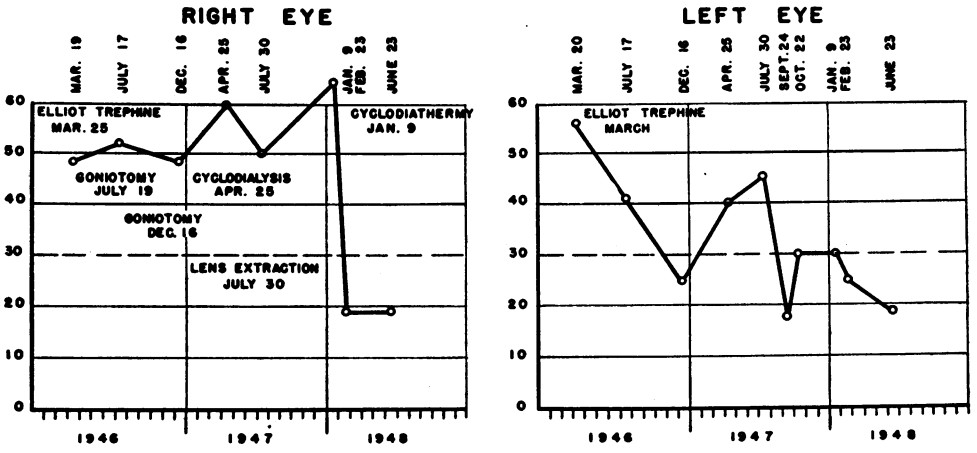

Fig. 3.

tion had taken place, it was observed that the lens in this eye was subluxated. Because the tension continued at 50 to 60 mm. Hg., the lens was removed with the thought that it could be contributing to the elevated tension. This was accomplished successfully without vitreous loss on July 30, 1947.

This procedure likewise failed to control the tension of the right eye, which was 64 mm. Hg. on January 9, 1948. Because the child was having considerable pain and the parents wanted everything possible done to retain the eye and the light perception which was still present, a cyclodiathermy operation was done. On subsequent occasions the tension in his right eye has been within normal limits. The left eye gradually became phthisical.

Result: Left eye: blind, phthisical, following Elliot trephine. Right eye: light perception. Goniotomy failed as secondary procedure.

CASE 4.—N. S., a 4-month-old baby boy, was seen through the courtesy of Dr. Francis Heed Adler on March 28, 1946. The child had been photophobic since birth. His parents had noticed that his corneas had become cloudy during the preceding month. He had been born at full term following an uneventful pregnancy. His development had been normal. There was no blindness in his family. General physical examination was negative. A Kahn test was negative.

Examination of Eyes:

Visual Acuity: He was attracted by moving objects before either eye.

External Examination: The eyelids were normal. The palpebral fissures were slightly widened. Ocular motility was normal. Each cornea was enlarged, the right being about 13 mm., and the left 14 mm. in diameter. Photophobia was marked. His pupillary reactions to light were intact. His conjunctiva was hyperemic but there was no discharge.

Slit-lamp Examination: Both corneas were hazy. Ruptures of Descemet's membrane were present in each eye.

Ophthalmoscopic Examination: This could not be done because of the clouding of the corneas.

Ocular Tension: O.D.: 38 mm. Hg., O.S.: 35 mm. Hg. (7.5 weight).

Impression: Congenital glaucoma, bilateral.

Subsequent Clinical Course: Bilateral Elliot corneoscleral trephine operations were done during the 2 weeks subsequent to March 28, 1946. At that time we had not as yet employed goniotomy in the treatment of congenital glaucoma. No operative complications were encountered and convalescence was uneventful. Miotics were employed postoperatively and he was re-examined at frequent intervals. Filtering blebs did not develop and the tension of each eye was only temporarily controlled. On May 20, 1946, it was found to be 40 mm. Hg. in each eye (Figure 4). Both corneas were again cloudy and edematous. During June and July, the cloudiness of the cornea continued and the finger tension remained elevated in each eye.

On July 29, 1946, therefore, a goniotomy was done on his right eye. Operation and convalescence were uneventful. Marked improvement in the eye resulted. The cornea of the operated eye

cleared but the unoperated left eye remained cloudy during the following 6 weeks. Because of the seemingly excellent result on the right eye, a goniotomy was performed on the left eye on September 9, 1946. The procedure was again done without complication. He was seen at 3-month intervals after this operation until December, 1947. Since then, the intervals have been increased to 6 months. During this time, his tension has been recorded between 17 and 30 mm. Hg. His corneas have continued to remain clear.

Following the goniotomies, ophthalmoscopic examination was easily carried out. His fundi were found to be very myopic, seen with a −11.00 lens on each side. The discs were large. No glaucomatous cups or atrophy were present.

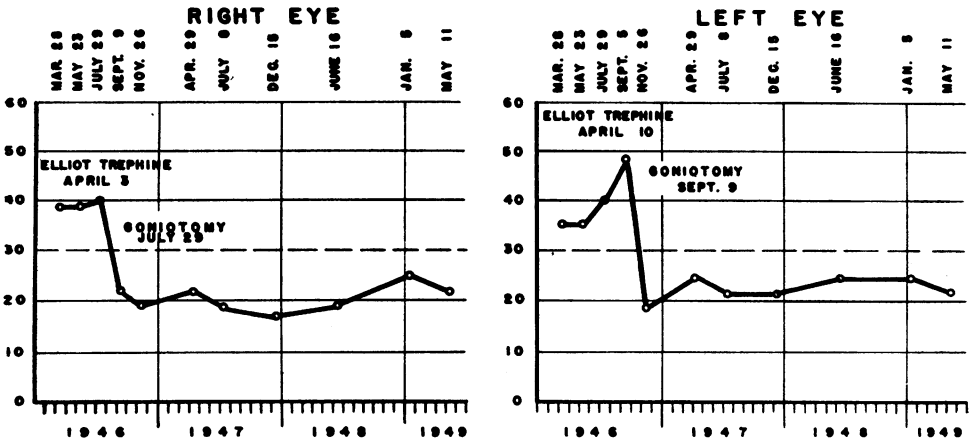

Fig. 4.

Postoperative gonioscopic examination revealed peripheral anterior synechiae at the site of the goniotomy in the right eye. None was seen in the left. He seems to have normal visual function except for high myopia (Figure 5).

Result: Tension controlled by goniotomies after corneoscleral trephine had failed, bilateral.

CASE 5.—J. M., a 4-month-old baby boy, was admitted to the Eye Clinic of the Hospital of the University of Pennsylvania on November 19, 1946. At birth, his eyes were observed to be larger than normal and he was sensitive to light. One week before being brought to our clinic, each cornea had become cloudy. His birth had been spontaneous, following a full-term, uncomplicated pregnancy.

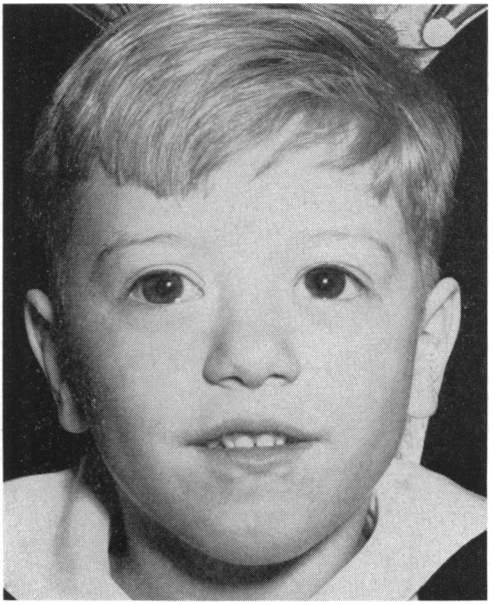

Fig. 2.—(Case 1, H. W. B.)—Photograph taken at age 4½ years (3 years after goniotomy O.D., 1 year after cyclodiathermy O.D. Approximately 2½ years following goniotomy O.S.).

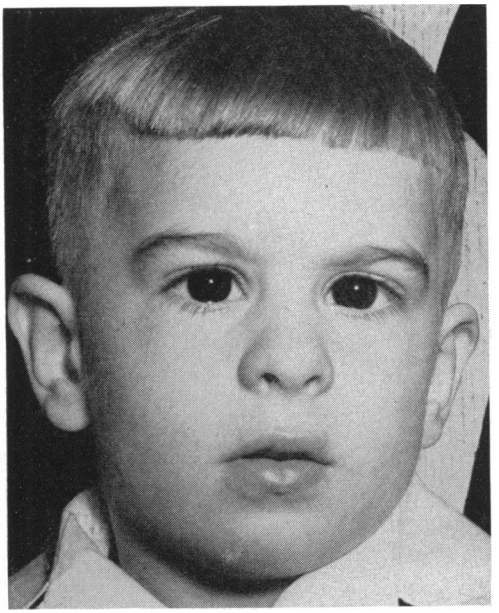

Fig. 5.—(Case 4, N. S.)—Photograph taken at 3½ years of age (2 years, 8 months after goniotomy O.D., 2 years, 6 months O.S.).

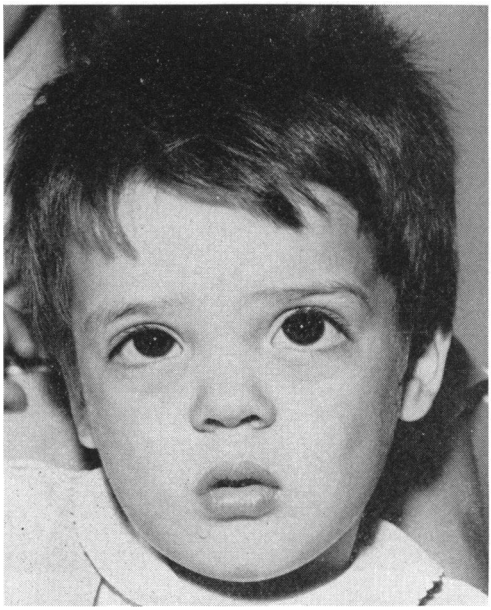

Fig. 7.—(Case 5, J. M.)—Photograph taken at 3 years of age (approximately 2½ years after goniotomy).

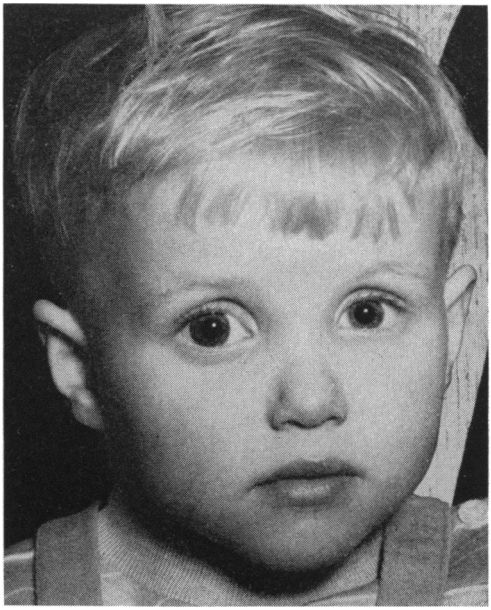

Fig. 9.—(Case 7, R. D.)—Photograph taken at 2½ years of age (2 years after goniotomy).

Postnatal development had been normal. There was no history of eye trouble or blindness in the family. General physical examination was negative. A Kahn test was negative.

Examination of Eyes:

External Examination: The eyelids were normal. Ocular motility seemed normal. Both corneas were enlarged, each being 13 mm. in diameter and each definitely cloudy. His pupils reacted to light. The conjunctiva and sclera were healthy.

Gonioscopic Examination: The corneas were too cloudy to permit visualization of the angles.

Ophthalmoscopic Examination: Although fundus detail was diffi-

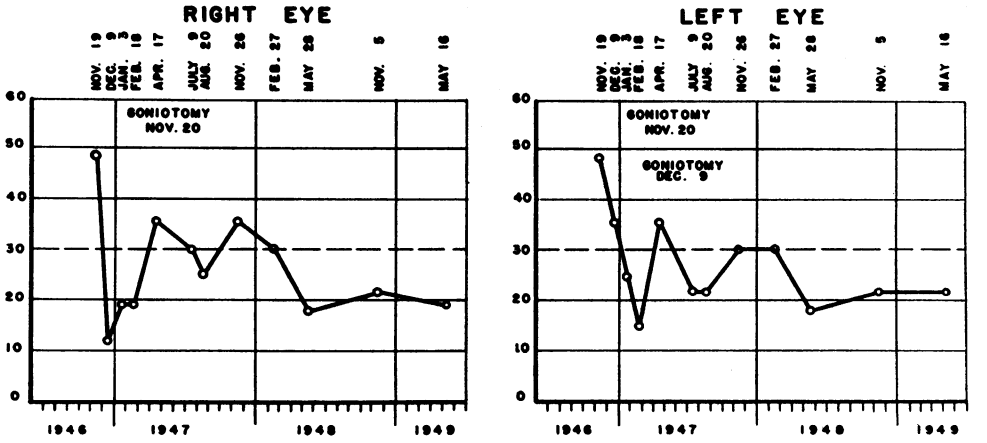

Fig. 6.

cult to see because of corneal haziness, the right disc appeared normal. The left nerve head appeared suspiciously cupped. The color of each disc seemed good.

Ocular Tension: O.D.: 40 mm. Hg., O.S.: 35 mm. Hg. (7.5 weight).

Impression: Congenital glaucoma, bilateral.

Subsequent Clinical Course: He was admitted to the Hospital of the University of Pennsylvania where a bilateral goniotomy was done on November 20, 1946. A small hyphemia occurred in the right eye, none in the left. A small iridodialysis was produced at 2:30 o'clock in the right eye and at 7:00 o'clock in the left. One week later, the tension was 12 mm. Hg. in the right eye and 25 mm.

Hg. in the left. The corneas were almost clear. On December 9, 1946, the ocular tension was found to have risen to 35 mm. Hg. in the left eye, so another goniotomy was performed on this eye (Figure 6). On January 3, 1947, the tension was 19 mm. Hg. in the right eye and 25 mm. Hg. in the left. The photophobia had disappeared. Typical ruptures were seen in Descemet's membrane of each eye. He has been seen at regular intervals, the tension remaining normal. His visual acuity seems excellent (Figure 7).

Result: Right eye: tension controlled by 1 goniotomy. Left eye: tension controlled by 2 goniotomies.

CASE 6.—S. L., a 4-month-old white girl, was first examined in the Department of Ophthalmology of the Hospital of the University of Pennsylvania on January 24, 1947, at the request of the Department of Pediatrics.

She had been born with a diffuse port wine nevus involving both sides of her face, neck and upper thorax. Her eyeballs had been larger than normal at birth. Delivery had been spontaneous, the pregnancy uncomplicated. General physical examination was negative except for the port wine nevus. A Kahn test was negative.

Examination of Eyes:

External Examination: Eyelids were normal except for a bilateral port wine nevus, part of the facial involvement. The fissures were slightly widened. The corneas were larger than normal. The right measured 12.5 mm. and the left 13 mm. in diameter. The anterior chambers were deep. The pupils were equal and reacted promptly to light. Ocular motility seemed normal.

Gonioscopic Examination: A large number of anomalous blood vessels were in the angle of the anterior chamber, many of which extended onto the iris.

Ophthalmoscopic Examination: The fundi appeared normal except for suspiciously large physiologic cups. The color of the discs was normal.

Ocular Tension: O.D.: 21 mm. Hg., O.S.: 19 mm. Hg. (7.5 weight).

Impression: A diagnosis of bilateral Sturge-Weber syndrome was considered but the ocular tension did not confirm it.

Subsequent Clinical Course: The parents were asked to bring the child in for another examination, which was done on March 29, 1947. At that time, the corneas were hazy. The tension was 48 mm. Hg. in the right eye and 54 mm. Hg. in the left.

On March 31, 1947, bilateral goniotomies were performed. A rather severe hyphemia occurred in each eye which absorbed during the week after operation. On April 7, 1947, the ocular tension was normal, but by April 27, although the corneas were clear, the ocular tension was again elevated. Anterior peripheral synechiae were seen with the gonioscope at the site of the goniotomy. Because of the presence of anomalous vessels in the angle, it was felt that the probable reason for the child's elevation in tension was anomalous vascularity of the uveal tract related to the capillary hemangiomas of the face. Further goniotomy was therefore not carried out, but the child was referred to the Department of Roentgenology for irradiation of the eyes with a Philips tube. This was done and the child has been followed by us in collaboration with the X-Ray and Pediatric Departments since that time.

Within a short time after beginning x-ray therapy, the ocular tension fell to normal and has remained so since. The child has been mentally retarded. In September of 1948 she began to have convulsions, for which she has been studied by the Pediatrics Department. It was thought that this was on the basis of an intracranial hemangioma but skull x-rays including an arteriogram were negative.

Result: Tension uncontrolled in each eye by goniotomy.

CASE 7.—R. D., an 8½-month-old baby boy, was first seen on May 26, 1947, through the courtesy of Dr. Samuel Phillips, Allentown, Pennsylvania. His parents had taken him to Dr. Phillips because they had noticed that the right eye was larger than the left and he had seemed sensitive to light. A diagnosis of buphthalmos was made by Dr. Phillips. His history was otherwise negative. The child was an identical twin, born spontaneously at full term. His twin brother was thought to have normal eyes. General physical examination was negative. A Kahn test was negative.

Examination of Eyes:

External Examination: The eyelids were normal. The right cornea was larger than the left, the respective measurements being 11 mm. and 10 mm. Both were somewhat cloudy. The right anterior chamber was slightly deeper than the left. His pupils reacted normally. Ocular motility seemed normal. The conjunctiva and sclera were healthy.

Slit-lamp Examination: The right cornea was hazy. Epithelial bedewing was present. Tears were noted in Descemet's membrane.

Ophthalmoscopic Examination: No definite abnormality was found. The anatomic landmarks were difficult to evaluate.

Ocular Tension: O.D.: 65 mm. Hg., O.S.: 40 mm. Hg. (7.5 weight).

Impression: Bilateral congenital glaucoma.

Subsequent Clinical Course: A bilateral goniotomy was done on May 26, 1947, which was followed by a rather marked hyphemia in each eye. They absorbed during the next few days. He has been followed at intervals of 3 months or less since that time, and his ocular tension has been found to fluctuate between 17 and 30 mm. Hg. in each eye (Figure 8). His corneas have remained clear and he uses his eyes normally (Figure 9).

Result: Tension controlled by goniotomy, bilateral.

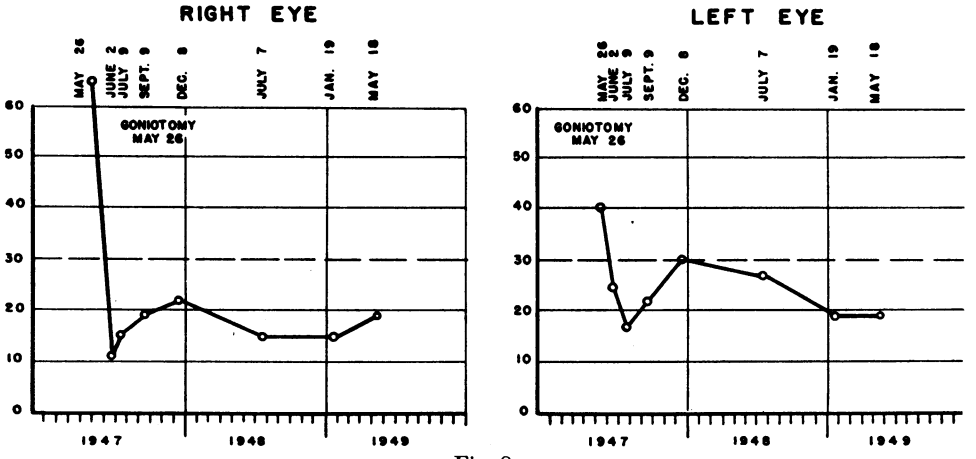

Fig. 8.

CASE 8.—R. D., an 8½-month-old baby boy, first examined on June 2, 1947, through the courtesy of Dr. Samuel Phillips, Allentown, Pennsylvania. This patient was referred for routine examination because his twin brother (Case 7) had congenital glaucoma. He had no symptoms of ocular disease. Like his brother he was born spontaneously at full term. His development had been entirely normal.

General physical examination was negative. A Kahn test was negative.

Examination of Eyes:

Visual Acuity: Used eyes normally.

External Examination: No ocular abnormality was found.

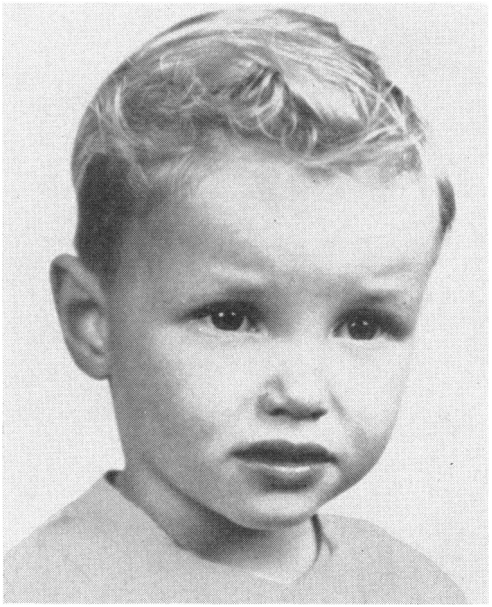

Fig. 11.—(Case 8, R. D.)—Photograph taken at 2½ years of age (nearly 2 years after goniotomy).

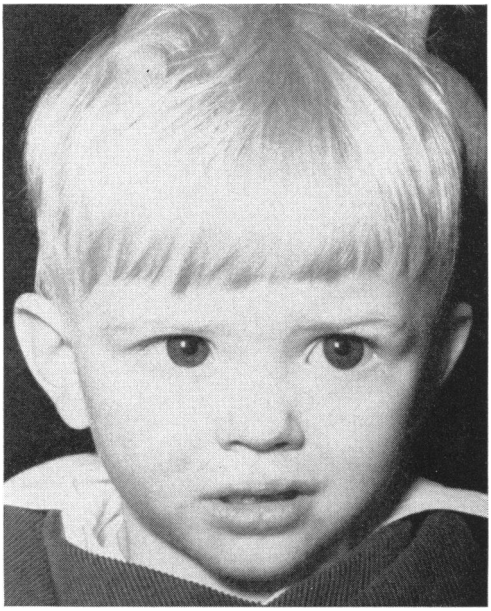

Fig. 13.—(Case 9, W. B.)—Photograph taken at 2 years of age (1½ years after goniotomy).

Slit-lamp Examination: His cornea, iris and lens were normal. The aqueous was clear.

Ophthalmoscopic Examination: No definite abnormality could be found.

Ocular Tension: O.D.: 40 mm. Hg., O.S.: 40 mm. Hg.

Impression: Probable bilateral congenital glaucoma.

Subsequent Clinical Course: The following day his tension was found to be 44 mm. Hg. in the right eye and 48 mm. Hg. in the left (7.5 weight). A goniotomy was therefore carried out on the right eye, which had the more elevated tension. Difficulty was encountered because of hemorrhage into the anterior chamber occurring just as the incision was started. Operation was therefore deferred

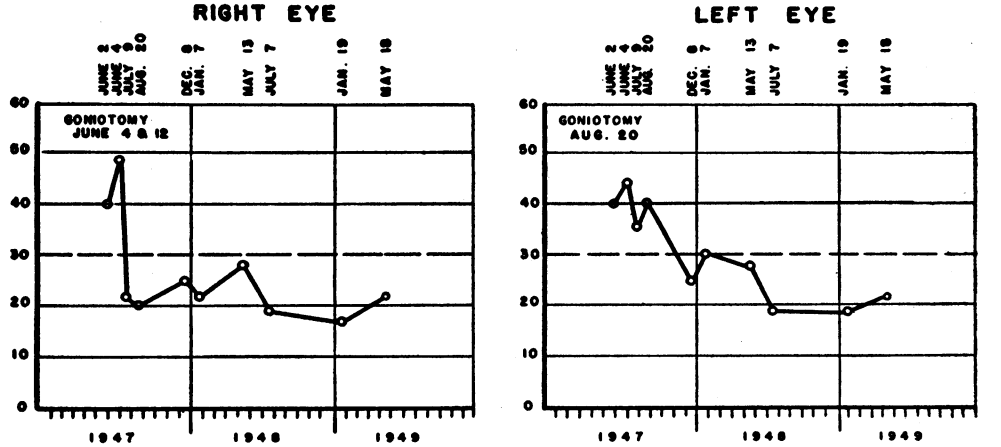

Fig. 10.

for 8 days until the eye had become quiet. The goniotomy was then completed in the right eye without difficulty. Because he ran a temperature following operation, he was discharged from the hospital without having the left eye operated.

He was readmitted to the hospital in August. The tension in the right eye was found to be normal, the left, 40 mm. Hg. (Figure 10). A goniotomy was therefore done on the left eye without operative difficulty on August 12, 1947. Convalescence was uneventful. He was discharged from the hospital in 2 days.

He also has been followed at regular intervals of no longer than 3 months. His tension has remained between 17 and 30 mm. Hg. and his eyes are apparently normal (Figure 11).

Result: Tension controlled by goniotomy, bilateral.

CASE 9.—W. B., a 5-month-old baby boy, was seen on December 30, 1947, through the courtesy of Dr. Samuel Phillips, Allentown, Pennsylvania. His eyes had been noticeably large since birth. The child had been very photophobic the month before admission and his corneas had become gray. The child was a fraternal twin. His sister's eyes were normal. Family history was negative except for strabismus. The child was born at full term following a normal pregnancy. Delivery was accomplished by low forceps. His development had been normal. General physical examination was negative. A Kahn test was negative.

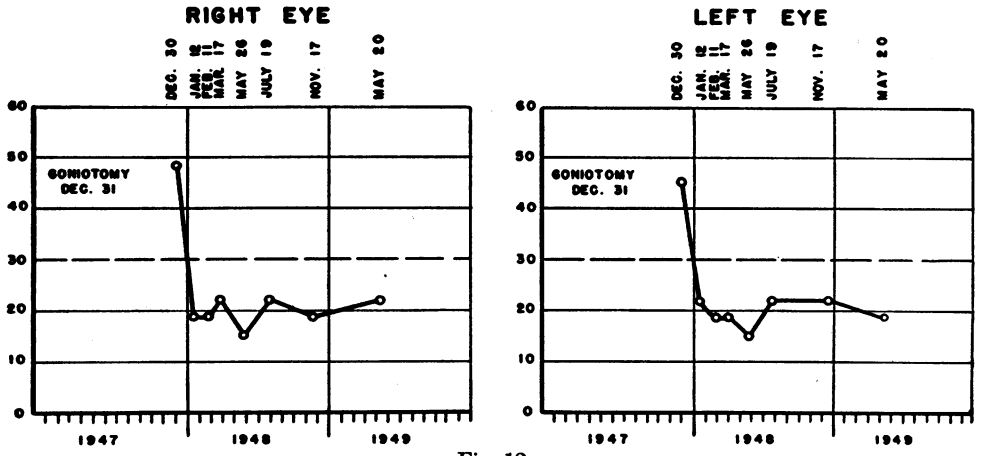

Fig. 12.

Examination of Eyes:

Visual Acuity: His eyes would follow a dim light.

External Examination: The palpebral fissures were slightly widened. Ocular rotations were full. Each cornea was large, measuring 13 mm. in diameter. The corneas were rather diffusely hazy. The anterior chambers were deep. The pupils reacted to light. Conjunctiva and sclera were healthy.

Slit-lamp Examination: Bedewing of the corneal epithelium was present in each eye. There was some haziness in the stroma.

Ophthalmoscopic and Gonioscopic Examinations: These were impossible due to the corneal haze.

Ocular Tension: O.D.: 45 mm. Hg., O.S.: 48 mm. Hg.

Impression: Congenital glaucoma, bilateral.

Subsequent Clinical Course: On December 31, 1947, bilateral goniotomies were performed under ether anesthesia. Convalescence

was uneventful. The child was discharged from the hospital on January 3. Since this time he has been followed at intervals of 6 weeks to 3 months. His ocular tension has never been above 22 mm. Hg. in either eye (Figure 12).

Subsequent ophthalmoscopic examination revealed that each disc was somewhat pale temporally and suspiciously cupped. Both corneas are clear (Figure 13).

Result: Tension controlled by goniotomy, bilateral.

Discussion

The results obtained from goniotomy used in the treatment of 16 eyes with congenital glaucoma support the claims made for the procedure by Barkan (Table 1). The tension was normalized in 11 eyes and presumably good visual acuity retained. The disease was so advanced in the 3 eyes where goniotomy was unsuccessful that failure was not surprising. Two of the eyes were practically blind at the time of operation and the third eye was not only greatly enlarged but had had an unsuccessful Elliot trephine prior to goniotomy. Goniotomy also failed to control the tension in either eye of a child who had bilateral congenital glaucoma associated with bilateral port wine nevus of the face and eyelids. This may represent a type of glaucoma which should not be treated by goniotomy because it is generally agreed that the cause of this entity is a nevus-like involvement of the uveal tract. Preoperative gonioscopic examination of these 2 eyes demonstrated anomalous vessels over the ciliary body which extended into the iris and probably explained the rather marked hemorrhage caused by the goniotomies.

Goniotomy was done as a primary operative procedure in 8 of the 11 eyes in which it was successful. All of these children were under 1 year of age when submitted to surgery. Ruptures of Descemet's membrane were absent in most of these eyes although some degree of corneal enlargement had occurred, and corneal clouding was present in the eyes of all patients but one. He was a boy whose identical twin had bilateral congenital glaucoma with enlargement of one cornea.

TABLE 1.—RESULTS OBTAINED FROM GONIOTOMY OPERATIONS

Case	*Eye*	*Age and Date of Operation*	*Preoperative Tension*	*Corneal Diameter*	*Previous Surgery*	*Result*
1. H. W. B.	O.D.	21 mos. June 19, 1946	33 mm. Hg.	14.0 mm. (nearly blind)	Seven Paracenteses	0
	O.S.	Aug. 6, 1947	38 mm. Hg.	13.0 mm.	Three Paracenteses	+
2. A. O. K.	O.S.	12 yrs. June 21, 1946	35–40 mm. Hg.	14.0 mm. (nearly blind)	None	0
3. T. B.	O.D.	13½ mos. July 19, 1946	52 mm. Hg.	14.0 mm. (nearly blind)	Trephine	0
4. N. S.	O.D.	8 mos. July 29, 1946	40 mm. Hg.	13.0 mm.	Trephine	+
	O.S.	Sept. 9, 1946	40 mm. Hg.	14.0 mm.	Trephine	+
5. J. M.	O.D.	4 mos. Nov. 20, 1946	40 mm. Hg.	13.0 mm.	None	+
	O.S.	Nov. 20, 1946 Dec. 9, 1946	35 mm. Hg.	13.0 mm.	None	+
6. S. L.	O.D.	6 mos. Mar. 31, 1947	48 mm. Hg.	12.5 mm. (Sturge-Weber)	None	0
	O.S.	Mar. 31, 1947	54 mm. Hg.	13.0 mm. (Sturge-Weber)	None	0
7. R. D.	O.D.	8½ mos. May 26, 1947	65 mm. Hg.	11.0 mm.	None	+
	O.S.	May 26, 1947	40 mm. Hg.	10.0 mm.	None	+
8. R. D.	O.D.	8½ mos. June 3, 1947 June 12, 1947	44 mm. Hg.	10.0 mm.	None	+
	O.S.	Aug. 12, 1947	48 mm. Hg.	10.0 mm.	None	+
9. W. B.	O.D.	5 mos. Dec. 31, 1947	45 mm. Hg.	13.0 mm.	None	+
	O.S.	Dec. 31, 1947	48 mm. Hg.	13.0 mm.	None	+

SUMMARY: Congenital Glaucoma—16 Eyes.
Goniotomy Successful—11 Eyes.
Goniotomy Failed—3 Eyes—Nearly Blind.
—2 Eyes—Sturge-Weber Syndrome

As a precautionary measure, his twin was examined. On 2 occasions the ocular tension was 40 mm. Hg. or above, so a goniotomy was carried out on each eye although the corneas had not been clouded.

Claims for the successful treatment of congenital glaucoma, particularly when a small number of cases is involved, must necessarily take into consideration the occasional spontaneous resolution of the disease which occurs. An example was the right eye of A. O. K. (Case 2), who at the age of 12 had normal tension in his right eye, 6/9 vision, a healthy optic nerve and a full visual field in spite of definite corneal enlargement and classical ruptures of Descemet's membrane from congenital glaucoma which had cleared spontaneously. The fellow eye showed similar corneal enlargement with ruptures of Descemet's membrane, but was nearly blind and had markedly elevated tension with optic atrophy.

Goniotomy possesses many advantages over other operations for congenital glaucoma. It seems very effective if done early. Reoperation was done only once in our series. There seems to be little danger from the procedure. As pointed out by Barkan, the chief danger is hemorrhage into the anterior chamber. This usually absorbs promptly. There is danger of injury to the ciliary body and of producing an iridodialysis. There have been no cases of sympathetic ophthalmia reported. Danger of subluxation of the lens must always be considered a possibility, particularly in enlarged eyes where the zonular fibers are taut. Several of our patients developed postoperative peripheral anterior synechiae but these can be avoided by the postoperative injection of air into the anterior chamber. We attempted to use the goniotomy lens twice in this series of patients but found that it offered no advantages and only served to make the operation more difficult.

The operation seems to be permanently successful. Patients reported in this paper have all been followed for 1½ years or longer and in none of the successfully operated eyes has the tension again become elevated. At the time of his last report, Barkan had followed some of his patients for as long as 10 years. No late complications have been reported nor observed by us. The operation, therefore, tends to cir-

cumvent the objections to the various filtration procedures, such as late infection, cataractous changes and others.

SUMMARY

(1) The tension in 11 of 14 eyes with congenital glaucoma was successfully lowered by goniotomy. (2) Failure occurred only in the eyes in which the disease was advanced. (3) Goniotomy failed to control the tension in 2 eyes of the same patient in which the elevated tension was associated with bilateral port wine nevus of the face and eyelids. (4) Goniotomy seems to be a fairly simple and safe procedure. (5) All of the successfully operated patients have been followed 2 years or longer.

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DISCUSSION

DR. FREDERICK C. CORDES, San Francisco, Calif.: I am very much interested in Dr. Scheie's report of his results with goniotomy in the treatment of congenital glaucoma. It has been my privilege to observe almost from the beginning the development of the operation by Dr. Otto Barkan.

Since its initial presentation it has been tried and condemned by a number of men. The failures in most cases, in my opinion, were the result of improper technic or its use in cases where it obviously would not be successful. As is true in all glaucoma operations, they are not 100% successful. However, in our experience, in the properly selected cases, goniotomy has given far better results than other procedures.

In order to properly understand the mode of action, indications and contraindications for goniotomy, it seems wise to emphasize the underlying changes in the eye and the mode of action of the operation.

In congenital glaucoma, when studied with the gonioscope, there is a characteristic picture. There is an abnormal insertion of the

iris by means of adventitious mesoblastic tissue into the angle wall anterior to its normal insertion, the point of attachment corresponding to the position of the anterior border of Schwalbe. As seen by the gonioscope this area of transition from the iris to the posterior surface of the cornea is covered by a gelatinous-looking semitransparent substance. In the successful operations the gonioscope reveals that this embryonic substance has been stripped from the angle. It is necessary, of course, that Schlemm's canal is capable of functioning if the operation is to be successful.

It has been recognized that early operation is necessary. Anderson's work throws some light on this observation. He found that in the eyes of early cases of congenital glaucoma that were examined microscopically, over 56% showed persistent or aberrant meshwork in the angle of the chamber. Also of great importance was the finding that in 75% of early cases Schlemm's canal was present, while it was absent in a very high percentage of the cases over 2½ years of age. Anderson feels that the canal becomes obliterated in these older cases as the result of some secondary changes.

The importance of early operation cannot be stressed too much.

As pointed out above, the longer the glaucoma persists the greater the probability that Schlemm's canal will be obliterated.

Another factor that makes early operation of importance concerns the cornea. We have learned from experience that the corneal clouding will clear entirely, provided that the process has not persisted so long that permanent changes are already present in the corneal stroma. Where the process has persisted too long the operation may reduce the tension, but not relieve the cloudiness of the cornea. It is well to remember that in some of the cases of longer standing if the tension is controlled the cornea will clear a good deal over a longer period of time.

In this operation meticulous attention to detail is essential.

In addition, repeated operation may be necessary before permanent reduction of tension can be obtained. In the cases thus far observed, once tension has been normalized it will remain that way. Goniotomy, then, is an operation for stripping or peeling abnormal embryonic tissue that obstructs Schlemm's canal from the angle wall. Quite obviously, it is important that it be done before Schlemm's canal is obliterated.

Dr. Scheie's further confirmation of Dr. Otto Barkan's work is an important contribution.

Dr. Conrad Berens, New York City: Dr. Scheie has given us a splendid paper on goniotomy and although my discussion is not on

this procedure, I noticed that in 2 cases he performed cyclodiathermy to control the tension when other operations, including goniotomy, failed. We have performed cycloelectrolysis (5 ma. of katholysis for 5 seconds) on 5 eyes with hydrophthalmos. It is not a large series, but it is a difficult disease to control and any suggestions for treatment which have proved at all successful are worthy of consideration. At first, the sclera was exposed, but now we go through the conjunctiva, using a 2 mm. conical electrode. Several of the eyes had been operated upon previously. These patients have been observed only for from 11 to 26 months, and in one of the eyes the operation had to be repeated. However, we have controlled the tension in 2 eyes without miotics and in 3 with miotics. It may be that cycloelectrolysis will have to be considered as a primary procedure in this disease which is so resistant to treatment.

DR. J. S. FRIEDENWALD, Baltimore, Md.: I was very glad when Dr. Scheie presented his report that he did not go into the problem of the mechanism by which this procedure acts, if and when it does act. I believe that a good deal of erroneous hypothesis has been built up on the report of Anderson several years ago of the finding of so-called persistent mesenchymal tissue about the anterior chamber angle. It has been my good fortune to be able to examine the eyes of a great many normal infants at autopsy, and the presence of persistent mesenchymal tissue quite similar to that described by Anderson in congenital glaucoma is a regular feature of the eyes of newborn infants, and is readily visible in most of them up to 6 months of age. Whether it is more persistent in congenital glaucoma than in normal eyes remains to be investigated, but no adequate control series has so far been published to indicate that the findings of Anderson represent in any way a pathologic condition etiologically related to congenital glaucoma.

DR. WENDELL L. HUGHES, Hempstead, Long Island, N. Y.: I noticed in a couple of patients reported that hemorrhage into the anterior chamber was noted. I wonder if Dr. Scheie has tried any thrombin in the anterior chamber at the time of operation in an attempt to control this. We have used this in some of our cases where bleeding from the iris has occurred, or is threatened, and have found it quite effective in helping to control bleeding from the iris.

Another point I want to ask Dr. Scheie about is, has he tried air before the goniotomy, in order to be able to visualize the anterior chamber angle? By putting in air with the special air goniotomy

knife, which is a goniotomy knife with a hollow handle (reported before this Society in 1945), we are able to balloon the anterior chamber after withdrawal of the aqueous, and therefore visualize the anterior chamber angle quite well without a contact glass. This renders the exact application of the point of the needle much easier. I wonder if Dr. Scheie has tried that special knife.

DR. FRANCIS HEED ADLER, Philadelphia, Pa.: This series of cases is small, but I believe it speaks very favorably for the operation, and my impressions are that prior to Dr. Scheie's employment of it, in our hands, at least, about 100% of these cases ended up blind, so that I feel very enthusiastic about it at the present time.

I would like to ask Dr. Scheie what happened to the child with the nevus flammeus, and whether he found that x-ray was effective. He was using x-ray on them with the hope of obliterating some of the vessels that were seen in the angle.

DR. HAROLD G. SCHEIE, closing: I am grateful to the discussers for amplifying several points in the paper.

In reply to Dr. Hughes, we have not tried either thrombin or the preoperative injection of air.

The patient with bilateral congenital glaucoma associated with bilateral nevus flammeus, about whom Dr. Adler inquired, was followed for some time after the goniotomies were done. The tension remained in the neighborhood of 35 to 45 mm. Hg. Because the disease seemed to be progressing, each eye was irradiated with roentgen rays from a low voltage Philips tube. I believe 4 or 5 exposures were given at 3-week intervals, following which time the ocular tension has been normal in each eye. Whether this was coincidental with or because of the x-ray, I am uncertain. We do know that vessels of angiomatous lesions early in life are sensitive to irradiation and respond well. At any rate, following the x-ray therapy scattered pigmented lesions appeared in the periphery of each fundus, which could represent scarring as a result of resorption of anomalous vessels. Irradiation seems a logical approach to this type of condition.