STRUCTURAL CHANGES OF THE ANTERIOR CHAMBER ANGLE IN PRIMARY CONGENITAL GLAUCOMA WITH RESPECT TO NORMAL DEVELOPMENT

CAMBIOS ESTRUCTURALES DEL ÁNGULO DE LA CÁMARA ANTERIOR EN EL GLAUCOMA CONGÉNITO. COMPARACIÓN CON EL DESARROLLO NORMAL

ROJAS B¹, RAMÍREZ AI², DE-HOZ R¹, SALAZAR JJ², RAMÍREZ JM¹, TRIVIÑO A¹

ABSTRACT

Purpose: To compare findings of normal angles with those from primary congenital glaucoma in order to clarify the pathogenic mechanisms of the disease and to explain the success of surgical treatment in some of these patients.

Methods: Adult normal eyes from cadavers and fragments of surgical trabeculectomies from patients with primary congenital glaucoma previously treated with goniotomy were studied. Eyes were processed for examination using light microscopy and scanning electron microscopy techniques.

Results: The following was evident in congenital glaucoma: 1) high iris insertion; 2) no observable pre-trabecular membrane, but enlarged trabeculae with diminished inter-trabecular spaces; 3) Schlemm’s canal (SC) apparently normal, with vacuoles in the wall indicating normal functioning; 4) sectioning of the abnormal trabecular tissue during goniotomy allowed repositioning of the angle structures and hence the appearance of the angular recess.
CONCLUSIONS: Anomalies of the trabecular structures in primary congenital glaucoma do not always parallel an abnormal development of the SC and the collector channels. This fact could explain the success of goniotomy in this type of glaucoma (Arch Soc Esp Oftalmol 2006; 81: 65-72).

Key words: Eye, Schlemm’s canal, trabecular meshwork, congenital glaucoma, electron microscopy.

INTRODUCTION

Congenital glaucoma is a pediatric disease characterized by an increase of intra-ocular pressure (IOP), secondary to an abnormal development of the structures of the anterior chamber angle. The IOP increase produces morphological alterations which may result in blindness. Different classifications have been proposed (1) and several hypotheses have been postulated attempting to explain the physiopathology of primary congenital glaucoma. Barkan (2) and Worst (3) described the presence of a membrane which covered the angle and extended from Schwalbe’s line (SL) up to the trabecular meshwork, blocking the exit of the aqueous flow. Allen et al (4) postulated that the anterior chamber angle did not open completely because it produced an incomplete cleavage and a poor differentiation and organization of cells in the trabecular area. Shaffer (5) defended the existence of an abnormal insertion of the iris in the most pervious area of the trabecular meshwork due to an incomplete separation of the tissue during development. Maumenee (6) observed an abnormal insertion of the longitudinal and circular strands of the ciliary muscle in the trabecular fibers, which tended to compress the scleral spur and therefore pressing Schlemm’s canal (SC). Other authors have described the presence of amorphous or fibrous materials in the endothelial portion of the trabecular meshwork and in the intertrabecular spaces of the corneal-scleral trabecular mesh (7,8). Finally, the incomplete development or absence of SC has been postulated (5,9,10) in some cases. This absence of consensus about the ethiopathogeny of congenital glaucoma might explain why congenital glaucoma exhibit different behaviors and responses to treatments.

The purpose of this work is to study with histological techniques and scan electronic microscopy (SEM) the anterior chamber angle of eyes with congenital glaucoma and compare the results with those of normal human eyes in an attempt to clarify the pathogenic mechanisms of this disease and explain the success of surgical treatment for some of these patients.

SUBJECTS, MATERIAL AND METHODS

For this study 12 normal adult eyes were used from donations for cornea transplant and 4 fragments of trabeculectomy parts of patients with primary congenital glaucoma who had been previously treated with goniotomy. The tissues were processed for study with optical microscopy (OM) (10 human eyes and two trabeculectomy parts) and scan electronic microscopy (SEM) (two human eyes and two trabeculectomy parts). Of the trabeculectomy parts, 3 came from trabeculectomies performed in angle areas previously untreated with goniotomy (2 for study with OM and 1 with SEM).
and one, from a trabeculectomy performed in the transition area between the tissue severed by the goniotome and unsevered tissue (for analysis by means of SEM).

The tissues were processed applying the following protocols.

**Optical Microscopy (OM)**

The eyes were fixed in paraformaldehyde (PF) at 4% in phosphate buffer (TF) 0.1 M pH 7.4. After 5 hours of fixation, the anterior segment was detached from the posterior segment and maintained in the fixing solution for 24 hrs. Subsequently, the anterior segment was washed in saline phosphate buffer (SPB) and dehydrated in alcohols with increasing degrees. Thereafter, the segment was introduced in toluene and included in paraffin. Six-micron sagittal cross sections were made, subsequently dyed with hematoxiline-eosine, Unna-Tanzer or toluidine blue.

**Scan Electronic Microscopy (SEM)**

Two fragments of trabeculectomies and two normal eyes were fixed in glutaraldehyde at 2.5% in TF 0.1 M pH 7.4 for 12 hrs. Subsequently, these were washed in TF 0.1 M pH 7.4 and post-fixed in osmium tetra oxide at 1% for 2 hrs. Thereafter, washed in distilled water, dehydrated in ketones of increasing degrees, the critical point performed with liquid carbon dioxide and metalized with gold. Subsequently, mounted on metal stands with the anterior chamber angle facing up. The samples were observed and photographed with a SEM.

**RESULTS**

**Normal adult**

**A) OM**

In the iris-corneal angle of the normal adult, we observed that the intertrabecular spaces of the corneal-scleral trabecular meshwork exhibited an elongated shape. The light of Schlemm’s canal (SC) was perfectly visible as were the external collectors and intrascleral and deep surface plexus with a randomly distributed density. The ciliar processes were clearly differentiated and contained an abundance of blood vessels.

**B) SEM**

The trabecular meshwork appeared as a triangular mesh surrounding the anterior chamber (fig. 1A). The angle thereof was located in Descemet’s membrane forming Schwalbe’s line. The trabecular meshwork extended from Schwalbe’s line to the stroma of the iris and the anterior surface of the ciliar body. The trabecular meshwork was made up of small lamellas (arranged on top of each other) to

---

**Fig. 1: Electronic transmission microscope take of an adult iris-cornea angle.**

A,B: The trabecular meshwork (white arrow) is seen as a triangular fabric (A) formed by small lamellae (arrow) constituting a filtration mesh (B). C: Uveal trabeculum (arrow); D: Corneal-scleral trabeculum (arrow). E: Trabeculae made up of flattened strips of tissue (arrow) with variable size openings (asterisk). Iris (I); Sclera (S); Root of the iris (IR).
form a filtration grid (fig. 1A and B). In the trabecular meshwork two portions were identified, the uveal trabeculum and the corneal-scleral trabeculum. The former was located in the proximity of the anterior chamber and its trabeculae were derived from the root of the iris and the ciliar body (fig. 1C). The corneal-scleral trabeculum consisted in a network of lamellas extending from the scleral spur to Schwalbe’s line (fig. 1D). The corneal-scleral and external uveal trabeculae were made up of flattened strips of tissue. Among these bands variable size angular openings were found, with rounded corners (fig. 1E). Said openings had a circumferential direction, parallel to the surface of the corneal-scleral limbus (fig. 1E). In the innermost layer of the uveal trabeculum, close to the anterior chamber, the trabeculae exhibited a sort of radially arranged rounded threads which defined large ovoid, circular or rhomboid-shaped spaced, forming a mesh (fig. 1C).

Congenital glaucoma

A) OM

The fragments of the trabeculectomies exhibited masses of amorphous material at the level of the trabecular meshwork and in the juxta-canalicular tissue. Said material, made up of homogeneous waste material, produced an increase in the width of the trabeculae and a considerable reduction of the intertrabecular spaces. The SC did not exhibit alterations.

B) SEM

In the congenital glaucoma preparations, we observed alterations in the insertion of the iris (fig. 2A and B), which was far forward of the scleral spur. The cross sections revealed that the root of the iris could be inserted in parallel to the SC (fig. 2B), or anterior and parallel to the SC (fig. 2A), in the proximity of the corneal tissue. This abnormal insertion determined the absence of angular recess (figs. 2A-C).

The thread-shaped trabeculae of the uveal trabeculum and the flattened trabeculae of the corneal-scleral trabeculum, both of which were observed in normal individuals, were not found in the subjects with congenital glaucoma. Instead, we observed a compact and quite homogeneous tissue with small openings, extending from the abnormal insertion of the iris to the SL (fig. 2C). This tissue was not different to that of the normal adult. It was the result of a modification of the trabecular meshwork tissue due to the increased width of the trabeculae which determined a reduction of the inter-trabecular spaces (fig. 2C,D).

The internal wall of the SC exhibited very bulky endothelial cells, which could indicate the presence of giant vacuoles inside (fig. 3A).

In one of the trabeculectomy parts it was possible to analyze the goniotomy incision exactly on the limit between the treated and non-treated area. An exploration of the area revealed that the goniotome had broken the trabecular tissue allowing the iris to rotate backward. The repositioning of the iris opened the angle in this area, exposing the angular recess (figs. 3B and C).

DISCUSSION

As other authors (11-15), our analysis of the trabeculectomy fragments of patients with primary congenital glaucoma, previously treated with goniotomy, has demonstrated structural changes in both the corneal-scleral as well as the uveal trabeculae. Said changes result in an altered position of the iris, giving the impression of a high insertion thereof. The term «giving the impression» is utilized because the insertion of the iris has a normal position and the appearance of a high insertion is given by the union of large uveal trabeculae, above or below, in the scleral spur. This observation has already been described by Kupfer and Ross (1971) (15), who postulated that mesodermic tissue waste of the iris would be responsible for the adhesion of the iris area close to the angular recess to the scleral spur, giving the impression of a high insertion of the iris.

One of the most controversial issues in congenital glaucoma is whether this tissue constitutes a proper membrane (2,16-19), or it is simply the result of a different structure formation of the trabecular tissue. In agreement with other authors (3,15,20,21), in our preparation we did not observe a membrane but trabeculae with larger sizes than those found in normal adults. Said tissue came from angle areas which were not sectioned by the goniotome because the trabeculectomies were performed in areas
where a previous goniotomy had not been carried out. Said increase in the size of the trabeculae is due mainly to the presence of mesenchimal tissue which, by reducing inter-trabecular spaces, enhances the accumulation of various materials (including erythrocytes). As other authors (15), we observed this amorphous material in the trabecular meshwork and also in the juxta-canalicular portion.

Some groups have postulated that the pathogeny of congenital glaucoma involves a lack in the SC development (5,9,10). In the fragments of trabeculectomies we did not find abnormalities (as per SEM) in the development of the SC. Quite the contrary, the configuration of the SC in the analyzed tissues was normal, to the point that we were able to observe giant vacuoles in the internal wall thereof.

In one of the patients with primary congenital glaucoma (previously intervened for goniotomy), we selected for trabeculectomy the transition zone between the tissue cut by the goniotome and the uncut tissue. The ultra-structural analysis of the tissue divided by the goniotome demonstrated that the configuration of the trabecular structures behind the section were normal. In accordance with Broughton (19), we believe that the mechanical effect of the cut could allow for a repositioning of the angular structures. The section of uveal trabeculae (the thickest ones) by the goniotome would facilitate a backward fall of the iris, exposing the scleral spur and the ciliar strip and therefore revealing the angular recess (20,22).

The above observations would explain the success of goniotomy as a treatment for primary congenital glaucoma. In our opinion, as the configuration of the angle is apparently normal in these patients, the goniotomy would cut the abnormal uveal trabecular tissue, facilitating the evacuation of the aqueous humor without resistance. In contrast,
in the primary congenital glaucoma cases which are not resolved with goniotomy it is possible that the functional failure lies in an increased resistance in the post-trabecular pathways. This increased resistance could be secondary to an accumulation of amorphous material in the juxta-canicular tissue (3,14), to an inadequate development of the SC or its collector conduits (5,10).

REFERENCES


ACKNOWLEDGMENTS

Agustín Fernández, del Centro de Microscopia Electrónica «Luis Bru» (Universidad Complutense de Madrid).

