SECONDARY GLAUCOMA: SURGICAL TREATMENT BASED ON THE IDEA OF THE CYCLODIALYSIS OPERATION AND ITS MODIFICATIONS

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The abstract.

The purpose of this review article is to analyze the elaborated surgical operations based on the idea of cyclodialysis. In the following, due to the short-term effect of this antiglaucomatous surgical interventions, ophthalmologists suggested various variants of explantodrainages with the purpose of making operations more efficient. The review has been made chronologically. One of the last stages in glaucoma surgery is the use of various allotransplants for expansion and preservation of cyclodialysis spaces. The main achievement is not only the formation of the cyclodialysis fissure, but also its long preservation in the open condition. In the Russian Eye and Plastic Surgery Center Alloplant biomaterials have been elaborated and produced for the surgical treatment not only for primary glaucoma but also for secondary one.

Key words: glaucoma, surgical treatment, cyclodialysis, explant, allografts, Alloplant biomaterials.

One of the founders of the operations on forming the outflow pathways of the intraocular fluid to the vessels of the ciliary body and on activating posterior, uvescleral way of the outflow is L.Heine [68] who suggested cyclodialysis in 1905. The mechanism of this surgical operation is based on creating the additional outflow pathway of the intraocular fluid (IOF) from the anterior chamber into the suprachorodial space. According to the author's opinion, reduction of the aqueous humour secretion is not excluded either. C.Toris and J.Pederson [75] confirmed the activization of the uveoscleral outflow while carrying out experiments on monkeys. Most ophthalmosurgeons came to the conclusion, that cyclodialysis is a low traumatic operative intervention which gives a short-term hypotensive effect because of the fast obliteration of the cyclodialysis fissure. It was its essential drawback [1, 34, 20, 43, 64] and later the method was modified [45]. There were suggested operations with the use of various auto-, allo, and xenografts to preserve outflow pathways for a longer period of time in cases of different forms of secondary glaucoma. They are a lacrimal sac, conjunctiva, rectus muscle of the eye, cornea, iris, sclera, crystalline lens capsule, arteries, veins, cartilage, amnion, allantois, chitin, etc. [39, 46, 7, 19, 10, 41, 11, 40, 22, 18, 32, 65, 66].

The mechanism of the fluid outflow improvement taking place in case of the dilatation of the supraciliary space by placing a scleral strip into it proved experimentally [55] provided the basis for the elaboration of the cyclodialysis surgery with the scleral stria implantation named "combined cyclodialysis" by A.P.Nesterov [36] and L.N.Kolesnikova et al [20] and "trabeculosclerocyclodialysis" by B.G.Orazmuhammedov [38]. The principle of the operation is close to that of iridocycloretraction suggested by M.M.Krasnov [23], but in the first case a scleral graft is fixed concentrically to the limbus, but not meridionally. The difference between the two operations is the following: the main purpose of iridocycloretraction is to dilate the anterior chamber angle in case of the close angle glaucoma [23, 61], the main goal of the described dilatation of the suprachorodial space combined with cyclodialysis is to stimulate the uveoscleral outflow tract [36, 20]. According to the similar method of dilating the supraciliary space suggested by L.N.Kolesnikov et al [20], alloscleral transplant [35] was used instead of autosclera.

Zaikova M.V. et al [16] have tested the allotranplantation of the perilimbal zone in clinical practice. T.A.Myasnikova has proved experimentally that the transplantation of the scleral part by means of a filter apparatus is possible in the secondary contusive glaucoma [33]. T.G.Kupriashvili [24] has performed a more detailed analysis of the results of the perilimbal zone allotransplantation in the surgical treatment of the developed and far-advanced stages of the primary glaucoma. He substituted the affected filtering scleral zone in the whole quadrant for the part of the donor drainage system of the same size containing trabecular apparatus with Schlemm's canal and collector tracks. There were no more publications on this way of treatment, however.

The advantage of all the autodrainage implants is that there is no immune reaction, and subsequently, they are perfectly biologically compatible. At the same time M. Murata [74] based on a big experimental material proved that the drainages from autotissue, scleral graft, in particular, are rapidly substituted, and cicatrized for the lack of the sufficient humor flow from the anterior chamber; further, outflow tracts, formed as a result of the surgery, are gradually blocked up.

The surgical operation of limbosclerectomy with the valvular drainage of the supraciliary space [25] was suggested. Limbectomy was carried out under the scleral flap and deep sclerectomy was performed in the distal sector of the bed. The common episcleral flap in the form of the split was brought into the formed cyclodialysis fissure from the limbus to the equator. The combined mechanism of the surgical intervention is similar to iridocycloretraction to activate the outflow of the anterior chamber humour towards the vessels of the ciliary body.

N. F. Bobrova [5] and A. F. Yumagulova [58] described cyclodialysis with the use of autoscleral flap-spacers during the treatment of the secondary glaucoma caused by burns and serious traumas with total cicatrical changes of the whole drainage system. In particular, while

performing scleroplasty of the drainage zone [5] the scleral striae introduced into the anterior chamber with one stage drainage zone resection stimulated the formation of the IOF outflow tract from the anterior chamber into the supraciliary space.

Chronologically the works dedicated to the study of the effectiveness of the cyclodialysis operation including explant drainages, can be divided into three main periods: the works written before 1930-40-s on the use of various wires, metal structures etc. The application of the explant drainages was first mentioned in 1866 when de Wecker used a golden wire, but he failed because of its dislocation [76]. The following attempts of the surgical interventions using drainages made of precious metals were also unsuccessful: the exterior end of the implant erupted through the conjunctiva with a tendency to be rejected and risk of infecting the eye [77]. D. Ciazzaro [63] made a drainage of the magnesium wire but he had difficulties connected with fixing the material and its rigidity. It was not applied any more because of high percentage of rejection.

During the second period of 1940-50-s, ophthalmologists referred to polymeric materials. The Russian ophthalmologist P.J.Bolgov [6] was the first to use it in his practice. Some time later G.Bietti [60] applied a polyethylene tube. That is how a new stage commenced in the surgical treatment of secondary glaucoma.

Since 1970-s there have appeared new opportunities in application of new synthetic drainages as new polymeric materials were developed. So one of the first drainages were suggested by V.J.Bedilo [4], B.F.Cherkunov [56]. They were made from hydrocolloid and lavsan and from foam polyurethane and first used by V. V. Volkov et al [8] for the treatment of secondary glaucoma.

D.S.Zhivotovsky [15] created drainages from polyvinylchloride and polyethylene in the form of microtubes with an internal clearance of 0,5mm long and filament. The author also pointed out a longer preservation of the outflow tracts.

L.Krejci [69, 70] used a drainage made from hydroxyethylmethacrylate containing 38% of water in order to dilate a cyclodialysis fissure in treating secondary glaucoma. This drainage is a plate 0,2mm thick, perforated with 8-10 parallel capillaries. It is difficult to speak about the effectiveness of the operation, as the author has operated on only 6 patients. B.Carenini et al. [62] has created a similar explant drainage and received encouraging results.

V.V. Volkov et al [19] carried out a comparative analysis to check the effectiveness of hypotensive influence of the drainages made from polyurethane film, synthetic fiber, fluoroplastic and silicone. The latter happened to be more reliable to normalize ophthalmotonus.

A.F.Jumagulova [58] applied silicone tubes to drain the anterior chamber, but the technique did not find wide usage in clinical practice because the external end of the tube was covered with a connective capsule.

In 1980 L.Kuljaca [71] created a V-shaped teflon drainage and clinically approbated it, but he faced the same difficulties as the previous researchers.

In 1986 [2] B.N.Alekseev and I.V.Kabanov suggested a drainage made from silicone rubber, kind of a tube 20-30mm long with 0,7-0,8 in the external diameter. 25 patients underwent an examination which showed, that in 84 % of cases IOF had normalized and in 64 % of the cases the vessels of the iris were reduced.

In troublesome cases of secondary glaucoma I.B. Kabanov et al [17] implanted a silicone drainage into the eye posterior chamber. In the same cases P.Lee and R.Ward [72] carried out an implantation from the anterior chamber of the eye into a vorticose vein. Both operations gave good results (75-79%).

I.O.Denisov [12] as a result of the in-depth study of the secondary neovascular glaucoma pathogenesis created drainages from teflon, hydrocellulose and silicone in the form of films and tubes. A remote hypotensive effect of the operation made up 70 %.

S.A.Malozhen [27, 26] formed a cyclodialysis fissure through which he implanted a silicone drainage into the anterior chamber for making two outflow pathways in cases of the eye anterior chamber structures affections. Ophthalmotonus in most of the patients (92%) normalized against the background of the medicamentous treatment.

M. Alper [59] implanted a dermalon filament into the suprachroidal space through the radial incisions of the sclera. When doing it the ciliary body did not exfoliate from the sclera.

To prolong safety of the cyclodialysis fissure in the advanced stages of glaucoma V.V.Strachov [42] carried out cyclodialysis by explanting silicone tubular drainage. However, the explants application did not find wide usage for dilating supraciliary and suprachoroidal spaces [34].

Alongside with the positive characteristics of all explant drainages, their use causes a number of complications, such as long postoperative hypotonia, shallow anterior chamber, macular edema, formation of connective tissue around the external end of a drainage, a tube-block. Besides there are some other complications. For example strabismus, endophalmitis, edema and dystrophy of the cornea, choroidal hemorrhages, subatrophy of an eyeball, retinal detachment, erosion of conjunctiva above the plate or tube with possible denudation or rejection of the implant [78].

Thus, formation of fissure spaces around the drainage similar at the most to the physiological outflow tracts of the anterior chamber humour is the most important factor of forming an outflow from the anterior chamber rather than the presence of pathways in the drainage. Most of the researchers share the opinion that the application of explant-drainages can be successful in cases of secondary and refractory glaucoma which can not be treated by traditional methods [2, 26, 53]. However, the truth is, that this trend in eye surgery has not yet reached the level which allows to undoubtedly replace traditional principles and methods of surgical treatment of glaucoma. Being one of the suggested techniques, implantation of "prostheses" in the drainage zone of an eye, first of all, must be carefully treated since first of all due to many various complications [58, 71, 78].

We began to use vessels of the ciliary body in order to create new tracts and to activate posterior outflow tracts of the intraocular fluid. So it was the beginning of the third period of using different drainages, including allotransplants for surgical treatment of the combined anthiglaucomatous surgeries. S.N.Feodorov et al [44] suggested deep sclerectomy surgery. Its mechanism is the following: the aqueous humor going from the anterior chamber, passes by the drainage system, flows into the "third" chamber of an eye the fundus of which is a ciliary body. There are lots of fenestrae in the capillary endothelium which provide permeability for the intraocular fluid. The surgery of secondary glaucoma has undergone some changes: deep layers of the sclera were dissected in the form of a strip perpendicularly to a limbus reducing the size of the dissected area [51, 52, 3].The authors reckon that the advantage of this modified operation consists in the creation of the directional flow of the chamber humour and decrease of the ophthalmotonus difference.

The authors noted that deep sclerectomy was the most effective in the initial stage of glaucoma (97 %) and the least effective – in the far-advanced stage. It depends on the better state of the eye vascular system, better state of the ciliary body in the first case, in particular. The operation appeared to be insufficiently effective in cases of the pronounced sclerosis and atrophic changes in tissues and vessels of the ciliary body which is frequently observed in advanced stages of glaucoma.

The technique of sinusotrabeculectomy described by A.P.Nesterov [34] is similar to the technique of deep sclerectomy. However the latter does not include dissection of the trabecular zone.

A.Girek, A.Szymanski [67] have reported about the achieved results of deep sclerectomy in open angle glaucoma (OAG). They indicated on the most often encountered cases of vascular coat detachment and intraocular hypertension within the first month after the operation, basically in patients with far-advanced and terminal stages of glaucoma. During the 3-9 years of the follow-up, normal intraocular pressure (IOP) was achieved in 81,7 % of cases, but in the far-advanced forms of glaucoma progressive reduction of visual acuity and narrowing of the visual field were observed reliably more. The authors came to the conclusion, that the given operation is most effective during early stages of glaucoma.

The comparative analysis of the "pure" deep sclerectomy and a combination of the latter with trabeculectomy carried out by V.F.Shmyreva et al. [57] showed, that deep sclerectomy in comparison with the traditional antiglaucomatous operations, has no advantages, as in most cases it is of fistulous nature and improves the outflow basically in the drainage system of the eye. Hydrodynamical parameters proved that fact: after deep sclerectomy they are lower than in the case of sclerectomy combined with trabeculectomy.

There were developed explant-drainages for treating various forms of secondary glaucoma [29, 47, 21] with the planned period of biodestruction furnished with, glycozaminoglycanes and dexazon [51, 53, 48, 49, 50], a valvular drainage from hydrogel based on polyhydroxyethylmethacrylate (***p-HEMA***) with the fixed content of water [28]. The purpose of such drainages application is to make stable the operatively formed outflow tracts for a long period of time. J.A.Cheglakov et al [48, 49] reported that 86,2 % of patients had normal IOP within 2,5 years in cases of traumatic, uveal, vascular and phacolytic forms of secondary glaucoma.

A.I.Eremenko and A.N.Stebljuk [13] combine deep sclerectomy with permeable drainage made on the basis of titaniumnickelid in order to prevent surplus cicatrization in secondary glaucoma.

It should be noted, that many operations with the elements of performing cyclodialysis are admitted as a method of choice to treat posttraumatic, postuveal and aphakic forms of secondary glaucoma [14]. But there is one more fact: cyclodialysis is more often used after opening of the anterior chamber which leads to the difference of pressure in the chambers of the eye, consequently, hypotension and other complications; a hypotensive effect in the post-operative period takes place within a short term because of the fast obliteration of cyclodialysis fissure [34, 20].

One of the important stages of the surgery to activate an uveoscleral outflow tract is an introduction of the scleral flap into the supraciliary space. However, the length of the flap introduced into the supraciliary space is very often insufficient and the elongation of the flaps by lengthening the scleral incision traumatizes the eye to a greater extent [54].

Providing an access of aqueous humour into the supraciliary space, it is necessary not only to perform a fissure between a scleral flap and the surface of the ciliary body but to preserve in the postoperative period the appropriate tract with the help of which humour could get into the posterior chamber of the eye from the anterior one. A sufficient flow of the intraocular fluid can to a certain extent prevent fast closure of the outflow tracts followed by the increase of ophthalmotonus.

It is necessary to keep in mind the fact, that the solution of such a serious and fundamental problem as surgical treatment of secondary glaucoma will be successful on condition of the elaboration of such transplantation material which would promote the formation of the new drainage system which would structurally be similar to the trabecular tissue. The Russian Eye and Plastic Surgery Center has accumulated great clinical experience on the application of the Alloplant biomaterials with positive properties [30, 37, 31, 73]. The developed antiglaucomatous operation of the supraciliary canalization system in secondary glaucoma with the use of the Alloplant technology includes the idea of cyclodialysis. The aim of the surgical intervention is to form a cyclodialysis fissure which separates the root of the iris and the ciliary body from the drainage zone and sclera with the help of two allograft-drainages. These drainages are elastic biomaterial (Alloplant) specially made for this intervention which contains various fractions of glycozaminoglycanes and compactly located bundles of collagenic and elastic fibres in its structure. The given structure provides a high module of elasticity of the biomaterial which is necessary for dilating the profile of the anterior chamber angle and suprauveal space. To provide an access of aqueous humour into this space, the formation of the fissure between the sclera and surface of the ciliary body is not enough. The main thing is to preserve during the postoperative period the appropriate tract with the help of which humor could get into the posterior chamber of the eye from the anterior one. A sufficient flow of the

intraocular fluid along the newly-formed outflow pathways can to a certain extent prevent fast closure followed by the increase of ophthalmotonus. So, only those surgical interventions can be perspective which will combine the properties of the drainage with an antiglaucomatous component and form not only one but several variants of the outflow pathways restoring the physiological mechanism of the outflow and circulation of the intraocular fluid.

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