1 Surgery of Vitreoretinal Disorders—Past, Present, and Future

Relja Živojnović

Pre-Gonin era: Retinal detachment has always been a dramatic and terrifying experience for the patient, and for the surgeon, a source of frustration for a long time. Practical knowledge in the nineteenth century was based on pathoanatomical observations, and the therapy consisted of drainage and bed rest. The invention and introduction of ophthalmoscopy by Helmholtz in 1851, enabling fundus visualization in vivo for the first time marked the decisive step in understanding and treatment of retinal detachment. Nevertheless, it took 70 long years to totally comprehend the course and dynamics of the pathological process. The main components of this process—traction, fluid, current in the eye as well as the hole in the retina were observed separately, but were not causally connected. The importance of particular components of the pathological process was either over- or underestimated, while the therapy itself relied on the surgeon's assumptions. Cutting of the» vitreous strands«–Deutschmann, Graefe; intraocular injection of various substitutes with or without drainage of subretinal fluid; extensive diathermy—Lagrange; shortening of the eyeball—Müller, combined with strict bed rest and positioning are some of many futile attempts whose rare positive results were at the most only temporary.

R. Živojnović (✉)
Stjepe Sarenca, 285340 Herceg Novi, Montenegro
e-mail: info@milosklinika.com

1.1 The Beginning of Retinal Surgery—Jules Gonin

In the early twentieth century, after extensive studies of pathological specimens, ophthalmoscopic observation of the dynamics of the pathological process and looking for holes in the retina, trying all the hitherto applied surgical methods in the treatment of retinal detachment, Jules Gonin, Lausanne, Switzerland, came to the epochal conclusion that a hole in the retina is the cause of detachment. Using Paquelin's thermocautery to perforate the eyeball on the spot of the defect and incarcerating its edges by the withdrawal of the needle, he achieved retinal reattachment. Using this method, he successfully reattached the retina in 40–50% of cases. After long years of disbelief and dismissal, he finally got recognition for his work at the international congress in Amsterdam in 1929. His enthusiastic followers were Arruga in Spain, Amsler in Switzerland, and Wewe in the Netherlands. However, in spite of the 40–50% success rate in the previously inoperable cases, a large number of patients still could not be treated successfully. The reason was that the treatment did not comprise the other two components of the pathological process, vitreoretinal traction and fluid current in the eye. Shortening of the eyeball to reduce its volume as introduced by Lindner and later by Wewe, based on earlier attempts by Müller, resulted in certain improvements.

U. Spandau et al. (eds.), *Retinal Detachment Surgery and Proliferative Vitreoretinopathy*,
https://doi.org/10.1007/978-3-031-11946-0_1

Ophthalmoscopy. As it was said before, in 1850, Helmholtz introduced ophthalmoscopy, which technically consisted of a strong source of light near the patient's head, a concave mirror with a hole in the middle through which the surgeon—by means of reflected light via convex lens—could see the lightened fundus. In the 1950s, that system was developed into a sophisticated ophthalmoscope with light and a system of lenses, which was used as both direct and indirect ophthalmoscope. Development of visualization was of crucial importance for the development of vitreoretinal surgery and had a curious course. In the early 1950s, Schepens, Boston, USA, and the Fison in London, UK, designed the binocular indirect ophthalmoscope, which was accepted and used in these countries at the time. In Germany, the Zeiss ophthalmoscope for direct and indirect ophthalmoscopy came into use very early. In the 1960s, it was replaced by the bonoscope, an indirect monocular ophthalmoscope with extra strong light. In France, indirect ophthalmoscopy was as good as unknown and direct ophthalmoscope was used in surgery, which culminated in the use of Goldmann´s three-mirror glass under the microscope. The superiority of the binocular indirect ophthalmoscope with the possibility of indentation of the periphery was obvious, so in the 1980s, it was eventually generally accepted. For diagnostic purposes, besides the ophthalmoscope, Goldmann's three-mirror glass and panfundoscope for its panoramic picture were used. In the 1990s, they were all replaced by 90D lens.

1.2 Scleral Indentation

The introduction of scleral indentation was a capital contribution to this surgery, as it simultaneously treated all three components of the pathological process: vitreoretinal traction, fluid current, and their consequence—the retinal hole. The first attempt at indentation—»buckle«—was reported in 1937, when Jess sutured a gauze tampon under Tenon's capsule. Although basically logical, this attempt did not find followers. The father of the»buckle« surgery was undoubtedly Ernst Custodis, Duesseldorf, Germany, who used a plastic "egzoplant" sutured on the sclera. This technique was soon accepted and increased positive results in the surgery to 80%. However, frequent complications of globe perforation due to the hardness of the plastic material, combined with surface diathermy, inspired surgeons in many countries to look for other solutions. For detachments with multiple holes in the periphery, Arruga introduced *cerclage equatorial*—circumferential buckle—by suturing a nylon thread through the sclera on the equator of the eyeball. The logic and simple use of this method were appealing. Perhaps that is why perforation of the globe during surgery and ischemia of the anterior segment postoperatively were rather frequent complications. The idea itself was perfected by Schepens, Boston, USA, who used softer material, i.e., silicone. An encircling band with or without a radial buckle, combined with diathermy replaced finally Arruga's cerclage. Complications with plastic material inspired Pofique and Spira Lyon, France to use biological material—human sclera. Lamellar scleral pocket—*poche scleral*—filled with pieces of the human sclera or sutured upon the sclera—*poche apportee*—filled with the same material were frequently used in the 1960s. At the same time, Kloeti, Zuerich, Switzerland, propagated the use of fascia lata as cerclage material. Naturally, biological materials did not cause any complications, but the effect of indentation was short-lived, and in some cases caused redetachment. Looking for new materials more or less ended, when Lincoff, New York, USA, introduced silastic sponge and replaced diathermy with cryocoagulation. In the early 1970s, this became the method of choice in the treatment of detachment and has been sustained as such up to the present time. Recently hydrogel as the material for indentation has not brought much change.

Retinopexy: The purpose of retinopexy is to create a chorioretinal scar and it has no impact on vitreoretinal traction. After the use of thermocautery in Gonin's time, surgery moved on to non-perforative diathermy as introduced by Pischel. Diathermy coagulation, technically improved by Wewe, was applied for many years. In the 1970s, Lincoff, following Bietti's (Rome, Italy) experience, combined the silastic buckle with cryocoagulation, which, properly used, did not damage the sclera. It should be mentioned that extensive use of diathermy but also of cryocoagulation, may have very serious consequences and provoke proliferative process in the eye. At the beginning of the 1960s, Meyer Schwickerath, Essen, Germany, introduced xenon photocoagulation, which opened a new chapter in retinopexy. Laser coagulation based on the same principle and introduced by Zweng and Little, USA, was technically much easier to use and replaced completely xenon photocoagulation. In this way, the chapter of retinopexy has been completed.

1.3 Intraocular Tamponade

Owing to his attempt in 1911 to treat retinal detachment by means of intravitreal air injection, Ohm can be regarded as the forerunner of tamponade. With much more understanding of the pathological process, Rosengren, Gothenburg, Sweden, used the air for tamponade in 1938. In the early 1970s, Norton, Miami, USA, introduced SF6, and in the early 1980s, Lincoff pioneered long-lasting gases, which have the advantage of long-lasting tamponade and the disadvantage of expansion under low pressure.

Tamponade is fully effective only when combined with indentation. Without indentation, propagated as fast and cheap surgery, it only has a temporary effect because of the persistence of vitreoretinal traction. From the early 1970s, the»buckle« surgery combined with cryocoagulation, drainage if necessary, with or without tamponade has become the method of choice in the treatment of retinal detachment and it is successful in 90–95% of detachments with the mobile retina. But it failed with detachments complicated by multiple equatorial ruptures, giant tears, and detachments caused by proliferative process.

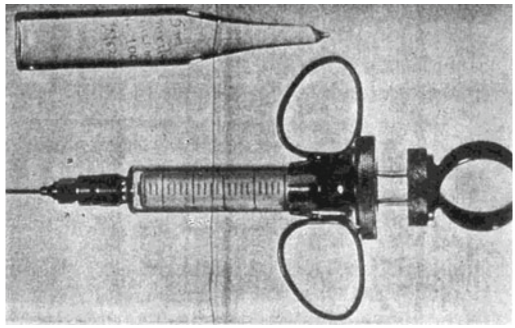

Fig. 1.1 Cibis syringe for injection of silicone oil

Introduction of silicone oil. In the 1970s, Paul Cibis, Saint Louis, USA, introduced silicone oil in retinal detachment surgery (Fig. 1.1). Under control of binocular ophthalmoscope in the reversed picture, using the surface tension of silicone oil and expansion of the silicone bubble, he tried to separate the detached retina from the changed vitreous and fibrotic membranes. At the same time, he tried to attach the retina by evacuating intraocular fluid. With successful results, he left silicone oil in the eye as permanent tamponade. By this extremely difficult technique, he achieved surprisingly good results in some cases that used to be inoperable. Probably owing to its difficult application, this technique had only a few followers in USA (Okun, Watzke). In the mid-1960s attempts of the use of this technique in some European countries were published—Moreau in France, Dufour in Switzerland, Liesenhof, Lund in Germany. Cibis' early death and legal problems concerning the use of silicone oil being an industrial product not registered by the FDA resulted in the restricted spread of this method. In Europe, surgeons did not use binocular ophthalmoscope and were not very familiar with the dynamics and consequences of pathological processes in the eye, which resulted in poor outcomes and the discontinuation of the use of silicone oil in Europe in the late 1960s.

Modern times. In the early 1970s John Scott, Cambridge, UK, impressed by Cibis' results with silicone oil, attempted the treatment of complex cases in which conventional technique was unsuccessful. Trying to separate fibrotic membranes and the changed vitreous body from the contracted retina by means of expansion of the silicone bubble, he also used intraocular instruments. He used the bent pick needle to lift membranes, the blunt flute needle for fluid evacuation, and scissors. The surgery was performed under the control of a binocular ophthalmoscope in the reversed picture. With a positive outcome, the central retina could be reattached and the fibrotic tissue and membranes pushed to the periphery. Silicone oil would stay as permanent tamponade preventing re-contraction of fibrotic tissue. With his skill, insight into the course of the pathological process, as well as by his enormous persistence, John Scott achieved remarkable results. Owing to the difficulty of the procedure itself and his good results, only a small number of surgeons could be compared to him, so Cambridge was the place of reference for patients from all over the world. With this method, John Scott made a huge step forward in the treatment of difficult cases, but even this method had its limitations. Giant tears with PVR, traumatic detachments with the incarcerated retina, diabetic tractional detachment, and others could not be treated successfully in this way. Permanent tamponade with silicone oil also caused complications in the long run.

At the end of the 1960s, David Kasner, Miami, USA, tried a new treatment of prolapse of the vitreous body during cataract surgery and trauma of the eye and called it open sky vitrectomy. Using cellulose sponges and scissors, he removed the prolapsed vitreous body. Through successful surgery, he proved that the vitreous body was not of vital importance to the eye. In 1970, the new technique inspired Robert Machemer, Miami, USA, with the technical assistance of J.M. Parel, to design an instrument that enabled entering the vitreous space through a relatively small opening, and under the microscope to remove the blurred vitreous body. The multifunctional instrument called Vitreous Infusion Suction Cutter was a revolutionary step in the history of vitreoretinal surgery. After a short time, O'Malley introduced a bimanual system with a separate source of light and standardized system of 20 gauge instruments. Pars plana vitrectomy opened new possibilities in vitreous body surgery, but it was not aimed at the treatment of retinal detachment. Even more, the fear of injuring the retina during surgery was great and comparable to the fear of loss of the vitreous body in earlier cataract surgery. In USA, the standard procedure for the treatment of retinal detachment for more than 10 years was the silastic buckle with cryopexy and possible gas tamponade. Complex cases of detachment with proliferative process usually were not operated on. The only kind of detachment in which vitrectomy was implemented was the detachment caused by a hole in the macula, which due to its location used to present a problem. In the past, indentation techniques were applied with modest success, such as the silver ring of Rosengren, the silver plomb of Gloor, Zurich, Switzerland, and others. For this kind of detachment, pars plana vitrectomy with removal of epiretinal membranes, gas tamponade, and positioning was the method of choice then and has remained so ever since. Recently, the relocation of the macula as introduced by Machemer in the 1990s is one more indication of the implementation of vitrectomy.

Pars plana vitrectomy has opened new possibilities for research of proliferative processes which now can also be followed in pathological specimens of the ocular tissue. In the late 1970s, Machemer described the proliferative process in the eye on the basis of acquired specimens and clinical experience, and introduced the familiar name Proliferative Vitreo Retinopathy (PVR), instead of MVR (Massive Vitreous Retraction).

Pars plana vitrectomy was rather hesitantly accepted in Europe by way of pioneers in particular countries: Kloeti in Switzerland, Laqua and Heimann in Germany, and Leaver in the UK. In the 1970s, Jean Haut, Paris, France, was the first to combine vitrectomy with silicone oil.

1.4 The New Concept

In the early 1970s, practicing retinal surgery in Rotterdam, the Netherlands, I was dissatisfied with my results. Visiting other centers in Europe—Zurich, Bonn, Paris—and comparing my work with that of the others, I did not notice major differences in results. After several visits to John Scott, I was convinced that his technique and approach were absolutely superior to anything I had seen before. In the late 1980s, I implemented his technique in surgery of a considerable number of patients and achieved results satisfying for that time. After a year, together with Diane Mertens, I abandoned binocular ophthalmoscopy. I switched to the surgical microscope with a contact lens (Fig. 1.2). Now I had a free hand and a direct image as in reality. For me, the surgical microscope is part of vitrectomy as a surgical technique.

I also abandoned combined vitrectomy with silicone oil, using it only as temporary tamponade. As the admitted patients were increasingly complex, it was soon obvious that this technique also had its limitations. In complex cases, when due to proliferative process the retina was contracted, incarcerated or shortened, removal of all membranes and scarred tissue was not sufficient to produce results we aspired to. The only solution for these cases appeared to be surgical intervention—retinotomy and retinectomy. Initially, only one-eyed patients in a desperate situation were treated in this manner. Nevertheless, I very soon managed to operate a considerable number of the most difficult, previously inoperable cases with favorable results.

I, therefore, established a new concept of treatment, which consisted of vitrectomy, meticulous removal of all epi- and subretinal membranes, retinal surgery, retinotomy, retinectomy, if necessary, laser coagulation, and temporary tamponade with silicone oil. After the first publications and frequent presentations at meetings, the introduction of retinal surgery in the arsenal of surgical measures was soon accepted and adopted.

At the very beginning of the development of this demanding technique, I was confronted with the absence of adequate instruments for this new kind of surgery. The presence of Ger Vijfvinkel, a technician in our hospital, was crucial for the development of new instruments (Fig. 1.3).

His frequent presence in the operating theater and observation of surgery resulted in prompt design and construction of adequate instruments. Besides numerous small instruments, we developed together the foot-driven silicone pump (Fig. 1.4), the back-flush needle with a silicone tip (Fig. 1.5), 4-port system, 25-gauge vitreous cutter and instruments, replaced Ando's plastic tacks with steel ones for perioperative use, etc. Ger Vijfvinkel with his inventiveness contributed considerably to the development of vitreoretinal surgery.

This new, more aggressive concept of vitreoretinal surgery was not associated with many postoperative complications. After the introduction of 6 o'clock iridectomy (Ando, Japan, 1986), the problem of the pupillary block was solved. Other complications could be ascribed to inadequate surgical technique or to the continuation of proliferative process which required frequent reoperations. This proliferative process was also often provoked by careless surgery. It should be mentioned that the pathological basis of all complex cases was the biological process

Fig. 1.2 The surgical microscope is an essential part of vitrectomy

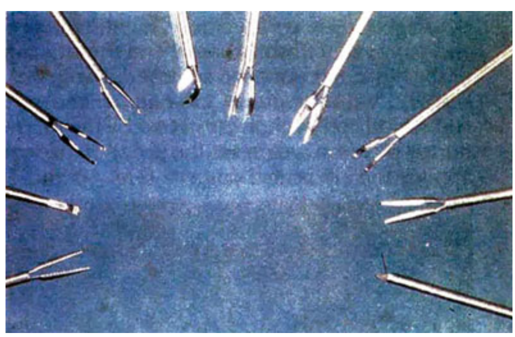

Fig. 1.3 Scissors and forceps

Fig. 1.4 Air driven silicone oil pump

Fig. 1.5 Back-flush needle with silicone tip

and that surgical therapy is only adequate and indicated in absence of better and more appropriate treatment.

In the last 20 years, no radical changes in therapy have taken place. Introducing PFCL (heavy liquid) Stanley Chang greatly simplified the surgical process. Double filling silicone with PFCL as used by Peperkamp, Rotterdam, Netherlands, in the prevention of inferior detachment gave positive results. Improved visualization of membranes by the use of colors—trypan blue—as well as triamcinolone acetonide for better visualization of vitreous cortex, made the surgical process easier and safer. The use of finer instruments, thinner vitreous cutters, as well as sutureless vitrectomy, simplified the course of surgery. Even with all this technical progress, meticulous removal of complete proliferative tissue before retinal surgery and injection of silicone oil remains an absolute must for the success of the operation.

A correctly performed »buckle« surgery with a binocular ophthalmoscope and its success rate of 90–95%, with the mobile retina, is practically complications-free. (Choroidal bleeding at drainage is the complication most frequently mentioned, which we practically reduced to zero by using the blunt lacrimal probe for penetration of the choroid after incision of the sclera.) This conventional surgery is much cheaper than vitrectomy in terms of both personnel and instruments. Pars plana vitrectomy in itself is an invasive method with more possible complications such as endophthalmitis, cataract, etc. However, nowadays there are few people ready to master indirect ophthalmoscopy and I am afraid that in the future, conventional surgery will lose the battle with 90D lens, wide angle microscope, and vitrectomy.

Finally, I would like to add a few comments. Development of the surgery has confirmed an old truth again: Not a single, even the most important step in development can exist alone but only builds on earlier achievements of its predecessors. Still, the development of vitreoretinal surgery was many times slowed down for seemingly incomprehensible reasons. For instance, it took many years before absolutely superior binocular ophthalmoscopy was generally accepted in Europe. Further, more than 10 years after the epochal invention of pars plana vitrectomy, the complex pathology was not treated in USA, while at the same time, such cases were successfully treated in Cambridge. How to explain it? Was it complacency, vanity, conservatism, or arrogance? Perhaps some of it all but the main reason was the poor flow of information. For a long time, retinal surgeons were perceived as curious people, almost nerds, and were isolated. Results of both successful and unsuccessful operations were considered inadequate. For quite a while, the prestigious bi-annual Gonin club meeting was almost the only place for the exchange of ideas and experiences. The presentation technique was weak and unconvincing. Mutual visits were not frequent or common, and learning and transfer of knowledge were not formalized, at least not in Europe.

This situation dramatically changed in the early 1980s. With the introduction of new surgical methods, new technology, and better results, interest in new surgery was on the rise. At numerous meetings, the new surgery was presented by new visual means: film, video, live surgery, in an attractive, instructive, and impressive way. Initially, that advancement was limited to the developed countries, but now, it has covered most countries that can afford it. Vitreoretinal surgery is not restricted to a small number of places. Instead, the number of centers, as well as the number of vitreoretinal surgeons, have multiplied.