Standard of acute vitreoretinal care

J. Ernest

The standard of acute vitreoretinal care (condition) in ophthalmology covers urgent conditions in ophthalmology requiring an immediate surgical solution in workplaces (vitreoretinal centres) providing highly specialised care.

- Characteristics of the term "acute vitreoretinal condition"
- Structure of specialised vitreoretinal centres
- Management of acute vitreoretinal care

Ad 1) Acute vitreoretinal conditions in ophthalmology cover a group of disorders which have specific common features. These are the risk of severe damage to sight if care is provided late or with an unjustified time delay. It relates to the following groups of ophthalmological disorders:

Detachment of the retina with recumbent macula

Even if detachment of the retina in itself is not an acute disorder, which mostly develops gradually, it has been demonstrated that postoperative results develop differently, depending on whether or not the macular area of the retina is detached. In the case that the macular area is not yet detached, the nutrition of the central part of the retina is maintained and in the same manner visual acuity is unlimited. The prognosis of an operation solution is good, and postoperative visual acuity is generally comparable with the preoperative condition. If the macular area of the retina is detached, a significant nutritional disorder of the most sensitive part of the retina may occur – neuroepithelia, and depending on the length of duration of the detachment this may lead to irreversible changes, i.e. permanent damage to visual acuity. It is desirable to commence with an operation solution within the shortest possible time after determination of the diagnosis of detachment of the retina. In the case of a hitherto recumbent macular area of the retina, it is necessary to consider an operation solution to be urgent, ideally within 24 hours of determination of the diagnosis. Each longer deferral of the operation involves a danger of progression of the detachment to the macular area of the retina with a risk of irreversible damage to sight.

Definition

Detachment of the retina is separation of the neurosensory part of the retina (NSR) from the underlying retinal pigment epithelium. Even if these layers are developmentally derived from the neuroectoderm, there is no actual anatomical connection between them. As a result, once they become separated from one another, a space opens up between them which means an impairment of the functional connections and a diminution of metabolic activity (Ghazi 2002). Repeat attachment of the NSR to the RPE is a condition for renewal of the functional connections and a return of the impaired visual functions. The retina in attached state is supported partially by metabolic forces and partly by mechanical forces (Marmor 2001). One of the metabolic forces which have an influence on retinal adhesion is oxygenation. Retinal adhesion is reduced post-mortem and is renewed with repeat oxygenation (Yao 1994, MARMOR 1995, KIM 1993), and is influenced by hypoxia and RPE activity on the active transport of water. The mechanical forces include the interphotoreceptor matrix (IPM) between the NSR and RPE and interdigitations between the projections of the RPE and the photoreceptors. Detachment of the retina does not mean a mere separation of the NSR from the RPE but also the destruction of the IPM. In the physiological state this functions as a glue connecting both layers, it has a structural layout and after detachment of the NSR from the RPE remains on both sides (Hageman 1995, Hageman 1988, Hollyfield 1989, Hageman 1991). The interdigitations between the projections of the RPE and photoreceptors secure the functional unit, and its function is above all continuous phagocytosis of the exterior segments of the photoreceptors, electrostatic interactions between the cell membranes and mechanical links between the cells (Gingell 1975, Marmor 2001). Separation of the NSR from the RPE causes an impairment of 3 fundamental metabolic processes: phagocytosis of the exterior segments of the photoreceptors, oxygenation of the IPM and electrostatic interactions between the cell membranes. After detachment of the retina, the biochemical processes between the NSR and RPE are halted, and there is an accumulation of sub-retinal fluid and a progressive loss of photoreceptors. If the detachment persists for a longer period, this leads to subsequent atrophy of the NSR. The period of detachment of the retina is fundamental for determining the prediction of return of visual functions following successful reattachment of the retina. Even if there are certain individual differences, it has been demonstrated in experimental conditions that the degeneration of receptors takes place as soon as 12 hours after detachment and after 24 to 72 hours almost all the cone cells and stems manifest various degrees of degeneration (Fischer Retina, Mosby). In clinical studies Burton observed a return of visual functions within a time interval from 1 to 72 days after detachment of the retina (Burton 1982). Whilst he observed a return of visual functions up to the 5th day after detachment (on average 20/50) after the 5th day a reversal occurred and the return of functions was worse by a row of Snellen's optotypes for each week up to 1 month of the observation. A range of further clinical studies support the opinion that the sole predictive factors of good visual functions for successful attachment of the retina are good preoperative visual acuity, young age and low elevation of the retina (Ross 2002, Burton 1982, Tani 1982, Ross 1988, Gruposso 1979, Johnston 1972, Kreissig 1977, Kusaka 1998, Davidorf 1975, Gundri 1974, Scott 2002, Hagimura 2000, Grizzard 1994). From a clinical perspective it is important that the longer the retina is detached, i.e. without supporting nutrition from the choroidea, the deeper and more irreversible are the degenerative changes of the NSR and the more severe the loss of visual acuity. Although inter-individual differences may exist, according to the experimental clinical studies (Guerin 1989, Berlin 1997, Chang 1995, Kroll 1969, Machemer 1971) there is a parallel between the period of detachment and the loss of visual acuity. The longer the time from detachment of the retina to the operation, the smaller the hope of return of visual acuity. Detachment of the retina in which the macula is attached has substantially better functional results in comparison with retinal detachment with a detached macula (Tani 1980, Scott 2002, Ross 2002, Wykoff 2010). The conclusion of these studies is a recommendation for timing of the operation in the case of de-

tachment of the retina with a recumbent macula within the shortest possible time. If the macula is detached, the functional results are worse if the operation takes place more than 5 days after the beginning of detachment (Ross 2002, Ross 1998, Burton 1982, Hartz 1992). In the case of detachment of the macula, an operation solution is not urgent, the operation may be performed as soon as this is enabled by the conditions of the surgical team, usually within 1 week.

Pathogenesis of retinal detachment

There are three basic types of retinal detachment: a) rhegmatogenic retinal detachment, which takes place on the basis of a crack or hole in the retina, b) tractional retinal detachment occurs when the traction forces of the vitreoretinal interface overpower the adhesive forces maintaining the retina in attached state and c) exudative (serous) retinal detachment, which occurs on the basis of a process (inflammation, tumour), the activity of which causes an accumulation of fluid in the subretinal cavity. The accumulation of fluid in the sub-retinal cavity is the fundamental and common symptom of all detachments. By far the most frequent type of retinal detachment is rhegmatogenic detachment, which may combine with the traction mechanism of detachment of the retina. With regard to the urgency of the indication for an operation solution and for the standard of acute vitreoretinal conditions in ophthalmology, the first two types of detachment are important – rhegmatolgenic and tractional retinal detachment. Exudative retinal detachment is not generally an acute disorder, frequently requires a time-consuming diagnosis and the treatment ensuing from it does not come within the framework of this standard.

Rhegmatogenic retinal detachment

Rhegmatogenic retinal detachment is characterised as follows: 1. by the existence of a liquefied vitreous area, 2. by traction forces in the area of the crack or hole in the retina, 3. by a crack or hole in the retina throughout its full thickness, which enables the penetration of fluid into the subretinal cavity. A combination of all three factors is necessary for the detachment to develop (Bardbury, 2001). Even in the case of a present crack or hole, detachment does not occur unless traction also simultaneously acts upon the area of the edges or lid of the crack (Byer, 1974). Also in the case of the presence of a crack or hole and a non-liquefied vitreous body, detachment of the retina is improbable. If traction of the area of the vitreoretinal interface is strong, this itself may lead to the formation of a crack. However, in the majority of cases cracks and holes appear on a basis of predisposed pathological changes of the retina. These are primarily degenerative processes of the periphery of the retina or macular area, trauma or high degenerative myopia. Cracks most frequently occur in the periphery of the retina, on a basis of grid degeneration, retinal tufts and pathologies of the area of the ora serrata (enclosed ora bay, retina pits) (Green, 1996). On the edges of grid degeneration we often find strong adherence of the pathologically altered vitreous area (Green, 2001). The development of the traction of the strongly adhering and pathologically altered vitreous area upon concurrent development of the crack or hole leads to localised detachment of the retina (Machemer, 1988). The migration of the liquefied vitreous area to the subretinal cavity supports a further separation of the NSR from the RPE in the case of persistent vitreoretinal traction, and is a factor of further development of detachment. Trauma is a less frequent, but nevertheless significant cause of retinal detachment. It constitutes approximately 15% of all detachments, mostly in younger patients (Bales, 1994). Blunt injuries to the eye without rupture of the eye represent approximately 70-85% of all traumatic retinal detachments (Giovinazzo, 1987). Whereas cracks in the retina as a consequence of degenerative processes are found in the great majority in the equatorial and pre-equatorial regions of the retina, trauma of the eye is mostly connected with a finding of retinal dialysis (tearing of the retina in the region of the ora serrata). Localisation of cracks is also different according to the etiology – as a result of degenerative processes it is usually in the superotemporal region, retinal dialyses as a consequence of trauma mostly in the inferonasal region (Mehta, 2000). Myopia is a significant risk factor for the occurrence of retinal detachment (EDCSG study, 1993). This risk increases with the degree of myopia (Haluzny, 1970). In the case of myopia, there is also a higher risk of development of grid degeneration and PVD (Celorio, 1991). With regard to the fact that in the case of myopes the retina is also thinner, high degenerative myopia represents a large risk for the development of retinal detachment, often bilateral (Grossniklaus, 1992).

Combined tractional and rhegmatogenic retinal detachment

Tractional retinal detachment occurs if the retina is separated from the RPE by traction force, upon an absence of a crack in the retina. These forces may be created by means of traction lanes or membranes forming during the remodelling of the vitreous area. This type of detachment is generally most frequent in the case of proliferative retinal or vitreoretinal disorders, such as diabetic proliferative retinopathy (PDR), proliferative vitreoretinopathy (PVR), retinopathy of premature (ROP) or as a consequence of perforating injury (Gregor, 1982, Clary, 1979). Combined tractional-rhegmatogenic detachment is the result of a combined action of traction of the vitreous area and retinal crack. Some rhegmatogenic detachments combine both mechanisms, i.e. the crack or hole in the retina and a significant tractional component, which ensues from the development of cell membranes on the surface of the retina. Such detachments are mostly flat, less frequent are bullous detachments, which are typical of the purely rhegmatogenic type. Combined tractional and rhegmatogenic detachments are generally linked with manifestations of PVR and are frequently a symptom of longer development of retinal detachment. PVR is a complication of rhegmatogenic retinal detachment, and often the most frequent cause of failure of an operational procedure, which occurs in 7-10% of cases (Bonet, 1996). The fundamental pathological process upon PVR is the growth and contraction of cell membranes on the internal retinal surface and the external surface of the cortical vitreous area (Campochiaro, 1986, Rachal, 1979). In the initial stage fibroblasts, RPE cells and glial cells play a significant role. Cellular reactions take place upon a background of hitherto not fully examined proliferations of Müller cells, astrocytes, pericytes, endothelial cells and a migration of microphages (Hisatomi, 2002). The contraction of fibrous membranes leads to a reopening of the cracks and holes, and a repeat detachment of the retina. The formation of membranes on the external retinal surface is indicated as subretinal fibrosis and is generally a manifestation of continuing PVR, and often the final image of untreated or unsuccessfully treated retinal detachment. Subretinal fibrosis impairs the intercellular connection between the NSR and RPE and prevents the regeneration of photoreceptors following successful operation attachment (Guerin, 1989, Lewis, 2003).

Cracks or holes without manifestations of detachment of the retina are found in approximately 5-10% of the population aged over 50 years (Byer, 2001,

Okun, 1961). Liquefaction (syneresis) of the vitreous area and its detachment (PVD) becomes more pronounced with age. We can observe a certain degree of liquefaction in almost 90% of persons aged over 40 years. At the age of 60-69 years PVD is present in 27%, in persons aged over 70 years it is present in 69%. For these reasons also, rhegmatogenic retinal detachment occurs more commonly at a more advanced age (Steinberg, 1989). Subclinical retinal detachment is classified as detachment of the retina in the surrounding area of a crack or hole lining within the scope of less than the PD (disc area). Manifest detachment (larger than 2 PD) is classified according to localisation as equatorial, oral or macular (Green, 1996, Ghazi, 2002).

The factors which lead to rhegmatogenic retinal detachment are a combination of degenerative changes to the retina and forces including traction of the vitreous area, movements of the liquefied vitreous area and traction in connection with the formation of epiretinal, intraretinal or subretinal glial proliferation – proliferative vitreoretinopathy (PVR). Upon an absence of tractional forces, development of retinal detachment does not usually occur even in the case of presence of cracks in the retina. Pathology of the vitreoretinal interface develops over time, frequently it is a part of the physiological ageing of the vitreous area. A combination of the traction forces of the periphery of the retina and rhegmatocenic changes creates the conditions for detachment of the retina. The development of the pathology can be observed in a detailed biomicroscopic examination, and it is possible to evaluate the degree of risk of retinal detachment. Subclinical detachment need not be perceived subjectively by the patient, the development of pathology is indicated by prodromal symptoms, phosphenes and vitreous turbidity. Upon the development of detachment and transmission over the equator, a defect of the field of vision appears, with a deterioration of visual acuity upon the development of vitreous turbidity. If detachment encroaches across the area of the macular region, a sharp deterioration of visual acuity occurs. Even though very rare cases of spontaneous attachment of the retina have been described, in the case of failure to resolve the condition, loss of vision is permanent. From numerous studies it ensues that the longer the retina is detached, the smaller the hope of improvement of visual functions even in the case of an otherwise successful operation with attachment of the retina (Wykoff, Hartz, D Skico, Ross, Ghazi).

Return of visual functions after attachment of the retina

From the experimental and clinical studies it ensues that if the retina is attached in the macula at the moment of the operation, the resulting visual functions remain on a good level (Tani, Scot, Wykoff, Ross). In the case that the retina is attached in the macula, no differences are observed in postoperative visual functions if the operation is performed immediately or within 5 days of determination of the diagnosis. However, as soon as the retina is detached in the macula, rapid degenerative intraretinal processes take place and the postoperative results are considerably worse if the operation takes place more than 5 days after diagnosis (Ross, Burton, Hartz). The conclusions of these studies indicate a requirement for an acute, immediate operation in cases where the macula is still attached and there are clear symptoms of the danger of progression and the risk of detachment of the macula (i.e. vitreous traction, vitreoretinal tractional membranes, anamnestic development of detachment, deteriorating visual acuity).

Principles of treatment of detached retina

The principle of treatment of a detached retina is attachment of the retina, closure of cracks or holes in the retina and the creation of fixed chorioretinal adhesions in the location of the crack and the surrounding area. Two techniques are used for the creation of fixed chorioretinal connections. The first is cryopexy, in which the outer path via the sclera of the retina and the choroidea is frozen in the place of indentation by a probe at a temperature of -70 to -80 degrees for the time essential in order to form adhesion. The second method is thermal adhesion via laser coagulation, either via an interior pathway upon PPV or an exterior laser coagulator following impression of the sclera in the location of the crack. The energy of the laser is absorbed by the RPE and the choroidea, and leads to the formation of a fixed chorioretinal scar.

Two fundamental surgical techniques have been developed for operational attachment of the retina and closure of cracks or holes – plombage, cryosurgical techniques and pars plana vitrectomy (PPV).

Plombage techniques (exterior approach):

Episcleral techniques (plombage, cerclage) function on a number of principles. Indentation of the sclera after the formation of a scleral fornix blocks the location of the crack, blocks the penetration of the fluid into the subretinal cavity and thus enables resorption of the subretinal fluid and reduces vitreoretinal traction in the location of the crack. The plombage technique reduces the tractional forces in the epiretinal cavity in the surrounding area of the crack. The cerclage fornix reduces transretinal traction by reducing the diameter and perimeter of the vitreous base. Plombage techniques have a positive effect in changing the geometry and physiology of the eye, on the other hand they involve secondary changes in the axial length, corneal topography and intraocular volume. The percentage of primary attachment of the retina after the performance of plombage technique is stated between 62-85% (Heimann, Miki, Brazitikos, Frame).

Pars plana vitrectomy (interior approach):

After the introduction of PPV in 1970, this technique became the method of solution for complicated types of rhegmatogenic retinal detachment. With the development of instrument techniques and the development of new vitrectomy instruments and appliances, PPV gradually began to be used as the primary treatment for all types of retinal detachment. The principle of the technique resides in the removal of the vitreous area using a knife of the vitrectom, mechanical attachment of the retina, direct treatment of retinal pathology and tamponade of the treated retina by intraocular tamponade. The principle of PPV technique is direct removal of vitreoretinal traction, which is considered to be the motor of retinal detachment. A component of PPV is direct treatment of retinal pathology, which resides in either laser coagulation of the crack and its surrounding area or external cryopexy of the crack under internal control. Intraocular tamponade is understood to mean tamponade of the retina at the end of the operation with air, a mixture of expansive gases or tamponade by silicon oil. The selection of intraocular tamponade is individual according to the character and type of retinal detachment and a range of other factors, and is the exclusive decision of the surgeon. The advantage of the PPV technique is more detailed peroperative diagnosis and evaluation of the pathology of the retina and the vitreoretinal interface. Frequently further pathology of the retina is found, which it was not possible to reveal during the preoperative examination and which is often the source of failure in the case

of plombage techniques. The percentage of primary attachment of the retina after PPV is stated between 64-100% (Ah-fat, Heinmann, Miki).
Even if each surgical technique has an advantage over the other in the case of a certain type of detachment, these techniques are to a certain extent substitutable. The selection of the technique is always the individual decision of the surgeon, and ensues from a range of factors such as the type of detachment, localisation and number of cracks, previous eye operations, age of patient, overall condition and a range of other factors. A number of comparative studies have compared the effectiveness of both techniques (Heimann, Miki, Bobry, Pournaras, Oshima, Brazitikos). The general recommendations upon selection of technique are as follows:
- Plombage techniques are statistically more beneficial for phakic eyes, upon occurrence of a solitary crack or hole, small scale retinal detachment, in the case of absence or minimal manifestations of PVR. They are also more suitable for younger patients.
- PPV is more beneficial for aphakic or artephakic eyes, upon occurrence of 2 or more cracks or holes, upon larger scale detachment, upon bullous retinal detachment, upon the presence of vitreoretinal traction, upon manifestations of haemorrhage in the vitreous area and vitreous turbidity. Indications for PPV are more pronounced manifestations of PVR and occurrence of posterior cracks which cannot be reached by plombage techniques. Retinal detachments where the thin sclera does not enable stitching of a seal or cerclage strip are more suitable for PPV.

Clinical recommendation for acute operation on retinal detachment

It is necessary to consider rhegmatogenic retinal detachment in which the macular area of the retina is still attached and where there is a risk of detachment of the macula to represent an urgent case for operation. Amongst the developmental factors are clinical detachment of the upper half of the retina, the character of cracks or holes in the detached retina, the occurrence of vitreoretinal tractional forces, as well as anamnestic progression of detachment or such progression demonstrated by examination, and loss of visual acuity. After determination of the diagnosis, the operation should be performed within the shortest possible time, and no later than 24 hours after the determination of the indication. The choice of surgical procedure is markedly individual and exclusively the jurisdiction of the operating surgeon. The selection of surgical procedure ensues primarily from the clinical finding and other significant factors such as anamnesis, age, condition of other eye, overall condition of patient and others.

Endophthalmitis

The term endophthalmitis is understood to mean an inflammation of intraocular structures either by an exogenous way (after operation on cataract, glaucoma, pars plana vitrectomy, perforating or penetrating eye injury, rupture or laceration of wall of eye) or by an endogenous way. A fundamental characteristic of endophthalmitis is inflammatory infiltration of the vitreous area by inflammatory cells, predominantly neutrophiles, a reproduction of bacteria and production of endotoxins. In the majority of cases the inflammatory infiltration is connected with a severe loss of vision, pain and the formation of a hypopyon. Further progression of inflammation may lead to panophthalmitis, corneal infiltration and perforation of the eye. The resulting condition may be phthisis of the eye with permanent blindness. The development of the disorder and inflammatory infiltration can often be observed over the course of a number of hours to days. Even despite technological advances in eye operations and pharmacological advances in the last decade, the number of cases of endophthalmitis is increasing substantially (Aberg 1997). The primary treatment technique of developing endophthalmitis is an urgent operation procedure with removal of the developing agent together with removal of endotoxins and instillation of antibiotics (Lemley 2007, Taban 2005, Becker 2007, Kuhn 2005). The speed of development of the disorder depends on the type and virulence of the agent and the size of the inoculum. As a result, the urgency of the operation solution ensues also from the clinical finding. This is within the range of a few hours at most. An immediate procedure is desirable, directly following the determination of the diagnosis and before full development of the inflammation with toxic damage to the neuroepethelium takes place (Kuhn 2005, Becker 2007). The prognosis upon timely identification of the disorder and timely indication for operation (PPV) is relatively good before the full development of the disorder, and enables maintenance of good visual functions. In the opposite case, in which the operation does not take place until the full development of the inflammation, it is not possible to expect satisfactory visual functions to be attained in the postoperative period (Kuhn 2005).

Acute postoperative endophthalmitis

Acute postoperative endophthalmitis occurs shortly after an operation on a cataract, glaucoma, PPV, perforating keratoplasty, intravitreal injections of pharmaceuticals, and less commonly after non-perforating operations (pterygium, glaucoma, strabismus, scleroplasty, scleral implants) within a period of 3 weeks after the operation. However, it most frequently occurs 3-5 days after the operation (Lemley, 2007). The most frequent manifestations are eye pain, swelling of the lids and conjunctivae, reddening of the eye, corneal edema, hypopyon, turbid optical media, cell infiltration in anterior chamber, in coatings of the artificial lens and in the vitreous area, formation of fibrin and fibrin mesh in eye, infiltration of the vitreous area, periphlebitis, retinal infiltration, retinal haemorrhage, edema of the disc of the optic nerve. In the EVS study 94.3% of patients with endophthalmitis had obscured vision, 82.1% reddening of the eye, 74% eye pain, 85% hypopyon, 79% retinal infiltration preventing view of the retina, 26% deterioration of vision to merely light projection. The EVS study evaluated the initial manifestations of endophthalmitis, which are reduction of visual acuity, progressive inflammatory infiltration of the vitreous area in which it is still possible to diagnose retinal blood vessels. These patients were not included in the study, as a result of which the results of the EVS study are distorted from the perspective of an acute approach to operation in the initial stages of development of inflammation. Cataract operation is a far more frequent intraocular operation and almost 90% of cases of endophthalmitis occur after this operation (Verbraeken 1995). Current estimates of the occurrence of acute postoperative endophthalmitis are between 0.08% and 0.68% (Javitt 1994, Norregaard 1997, Somani 1997, Aaberg 1998, Morlet 1998). The risk of endophthalmitis is paradoxically increasing despite the development of modern surgical techniques, evidently with a transition from sclerocorneal to corneal type of incision (Cooper 2003, Nagaki 2003). Each inflammatory reaction which is greater than postoperative irritation must be considered to constitute incipient endophthalmitis. It is then necessary to determine the diagnosis of endophthalmitis either upon clear manifestations of endophthalmitis, or in the case of borderline findings upon check-up examinations, in which it

is possible to record the progression and development of the inflammatory infiltration and penetration into the deeper layers and areas of the eye.

Chronic postoperative endophthalmitis

Chronic postoperative endophthalmitis is characterised by a gradual inflammation reaction usually occurring several weeks (more than 4 weeks) to months after a cataract operation (in rare cases glaucoma, PPV, intraocular application of pharmaceuticals). The microbial spectrum covers less virulent microorganisms, the most frequent of which are Propionibacterium acnes (63%), Staphylococcus species (16%), Candida parapsilosis (16%), Corynebacterium species (5%) (Fox 1991). Only in rare cases is there an occurrence of Actinomyces, Nocardia, Achromobacter, Cephalosporinum, Acremonium and Aspergillus species (Roussel 1991, Zimmermann 1993, Rocker 1998). Some of these, such as Staphylococcus epidermidis and Propionibacterium acnes may also cause acute postoperative endophthalmitis (Samson 2000, Kresloff 1998). The manifestations depend on the size of the bacterial inoculums and the virulence of bacteria. In clinical manifestations in chronic postoperative endophthalmitis, manifestatsions such as pain, sudden loss of visual acuity or reddening of the eye need not be present. The inflammation reaction is frequently mitigated by concurrently ongoing anti-inflammatory postoperative treatment and the clinical manifestations may be inconspicuous. Persistent irritation of the eye, fluctuating infiltration of inflammatory elements in the anterior chamber, intermittent deterioration of visual acuity, responding temporary to anti-inflammatory corticoid treatment, should indicate chronic postoperative endophthalmitis. A frequent manifestation is inflammatory precipitates on the endothelium of the cornea of the surface of the intraocular lens and in the capsular sac, goniscopically evident hypopyon (Kresloff 1998, Zambrano 1989). Identification of the bacterial agency is of key importance for the successful treatment of chronic endophthalmitis.

Diagnosis of endophthalmitis

Diagnosis of endophthalmitis is possible on the basis of a clinical examination with clearly demonstrated symptoms of endophthalmitis (see above). In the case of an unclear picture or borderline finding, an auxiliary technique may be ultrasound examination or ultrasound biomicroscopy of the eye. Both examinations document the inflammatory infiltration in the anterior and posterior segment, enabling registration of the progression and development of the infiltration in the direction into the posterior segment of the eye in a timely manner. On the basis of the development of the ultrasound examination, it is possible to indicate timely PPV in treatment of endophthalmitis before permanent toxic damage to the retina occurs due to toxins of bacteria, even if it is not possible to see this on the background from the clinical examination due to the turbid optical environments. It is suitable to repeat the ultrasound examination in the case of an unclear finding up to several times per day. The symptoms of progression of inflammation are an increase in subjective complaints of the patient, above all loss of visual acuity and increasing eye pain. It is necessary to differentiate endophthalmitis from toxoallergic postoperative reaction (toxic anterior segment syndrome – TASS syndrome), which is an expression of a sterile inflammation following the penetration of toxic substances, detergents, preservancia, bacterial toxins or cleansing components present in the infusion solutions. More pronounced irritation of the eye may also ensue from an excessive postoperative reaction of the patient in the case of immunodeficiency, due to excessive operation trauma, residual lens materials in the anterior chamber or overlooked residues of the nucleus of the lens. Tass syndrome can sometimes be differentiated by rapid onset (approximately 12-24 hours), positive reaction to local treatment and absence of bacterial cultures from bioptic material, as well as localisation of infiltration only in the anterior segment of the eye (McCray 1986).

Factors of development of postoperative endophthalmitis

There are factors and symptoms which support the diagnosis of endophthalmitis in contentious or borderline findings. These are dehiscence of the postoperative wound, filtration through the operational wound, inflammatory infiltration in the anterior chamber of the eye in connection with the surgery approach (e.g. towards the operational entry by service incision etc.), postoperative hypotonia of the eye, abscess in the area of the stitching, vitreous incarceration in the wound, eroding scleral stitches in the sclera fixation of the intraocular lens.

Microbiological characteristics

The most frequent cause of acute and chronic endophthalmitis is bacteria. Fungal and yeastlike endophthalmitis is rare, most often in connection with the use of contaminated solutions during a cataract operation (McCray 1986). The cause of endophthalmitis is usually microorganisms present in the actual periocular bacterial flora, which enter the operating field through the operation (Han 1996, Speaker 1991). In the EVS study, of demonstrated bacterial contamination 94.2% was of Gram position bacteria, of which 70% represented coagulation--negative Staphylococcus, 9.9% Staphylococcus Aureus, 9% Staphylococcus species and 2.2% Enterococcus species. Various Gram-negative cultures formed 5.9% of cultivations (Han 1996). Demonstration of bacterial infection encounters a range of technical problems. In the EVS study bacterial culture was demonstrated in only 69% (Han 1996). There are several reasons for the low rate of demonstration of bacterial infection. The size of the bacterial inoculums may be small for demonstration due to the influence of mostly already commenced treatment. Some bacteria, such as Staphylococcus epidermidis may be spontaneously liquidated during the course of the inflammatory response of the organism (Meredith 1990). Some bacteria (e.g. Propionibacterium acnes) are technically very difficult to cultivate in an artificial medium (Bauman 1992). The role of polymerase chain reaction (PCR) for diagnosis and better identification of the bacterial agent is promising, nevertheless it is not yet commonly available at all workplaces in the Czech Republic.

Treatment of endophthalmitis

Effective treatment of endophthalmitis covers prevention, timely identification of the initial symptoms and active treatment. Pars plana vitrectomy (PPV) has several potential advantages for the treatment of both acute and chronic endophthalmitis. These include reduction of bacterial microorganisms from the closed vitreous area, removal of endo and exotoxins, inflammatory material and cleansing of the turbid optic environment. An important factor is the role of sampling of material for microbiological processing and targeted installation of antibiotics according to sensitivity in laboratory processing. A potential disadvantage is the necessity for sophisticated medications, a qualified surgical team and an operating theatre for vitreoretinal surgery. In the case of a clearly determined diagnosis of endophthalmitis and signs of its development, PPV represents the sole technique enabling halting of the inflammatory process and thus preservation of satisfactory visual functions. In the case of timely indication of PPV, if severe loss of vision

has not occurred and the inflammatory process is in its initial stages of development it is possible to preserve good visual functions, unlike resolution of endophthalmitis in the stage of a developed process (Kuhn 2005, Lemley 2007). Previous recommendations from the now less respected EVS study of 1995 found benefit of PPV only for stages of endophthalmitis in which visual acuity had deteriorated to mere light projection (2). Indications for PPV were based only on the values of visual acuity and did not respect the clinical appearance and course of endophthalmitis. The recommendation also included the performance of only limited vitrectomy, leaving the cortical vitreous body. Contemporary observations have demonstrated that even in the case of installation of antibiotics into the vitreous area, leaving a thin layer of the cortex of the vitreous body with residues of inflammatory material, bacteria, toxins and inflammatory components means a continuation of toxic damage to the retina and further pathological changes such as vascular inflammation and macular edema (Kuhn 2005, Taban 2005, Becker 2007, Lemley 2007). In an extensive study, upon timely indication of PPV, Kuhn recorded a preservation of visual acuity of 6/12 or better in 91% of cases, as opposed to a mere 53% in the EVS study (Kuhn 2005). Detachment of the retina did not develop in any of the observed eyes, whereas in the EVS study detachment of the retina occurred in 8.3% of cases. A range of publications have demonstrated that the conception based on the EVS study is obsolete, and in the majority of developed and developing countries worldwide this has been abandoned by vitroretinal specialists.
Current indication for PPV covers clear manifestations of endophthalmitis (see above), in which the symptoms are progression into the vitreous area and formation of inflammatory exudates or infiltration in the posterior segment of the eye. Clinically a correlate is loss of reflex, loss of differentiation of structures of the retina and the development of manifestations during observation over the course of 24 hours.

PPV technique

In principle PPV should be a three--way 20, 23 or 25 G (infusion entry, light source and vitrectomy) procedure. The operation should be performed at workplaces with experience of performing vitrectomies – Vitreoretinal centres (VRC), with the possibility of 24 hour operating availability. The principle of the operation is complete removal of the vitreous area, maximum removal of the inflammatory materials from the eye. In the case of turbid optical media or turbidity of the cornea, it is suitable to perform PPV with temporary keratoprothesis, followed by removal of the fibrin and inflammatory membranes in the anterior chamber of the eye and of the fontal surface of the intraocular lens. By means of PPV maximum removal of the posterior capsule behind the intraocular lens and removal of the inflammatory infiltration from the sac. If it is not possible to remove the inflammatory components from the sac completely, the method of choice is removal of the intraocular lens and the capsular sac. At the beginning of PPV it is essential to perform sampling on a bacterial cultivation from a sample of approx. 0.5 ml-1 ml, ideally in two samples, on both an aerobic and non-aerobic cultivation and cultivation on mould. After sampling on the cultivation, a component of PPV is installation of antibiotics into the infusion solution with which the vitreous area is filled (rinsed). The choice of antibiotics depends on the clinical appearance of the endophthalmitis. According to contemporary observations and results of randomised clinical trials, the most effective treatment with the widest antibacterial spectrum is a combination of intravitreal installed Vancomycin and ceftazidim (Maguire 2008, Kuhn 2005, Becker 2005, Taban 2005, Saha 2009). In certain cases ceftazidim can be substituted with Amikacin (Lemley 2007, Werner 2006). A combination of these antibiotics covers 99.4% of all infectious microorganisms (Werner 2006). At present new antibiotics are appearing with an improved penetration into the vitreous area in both local application and in general administration (Moxifloxacin, Gatifloxacin), which are also very effective in intravitreal application and are well tolerated by sensitive neuroepethelia (Kuhn 2005, Ng 2005, Miller 2006). The aim of vitrectomy is the complete removal of the vitreous area, including cortical, the performance of ablation of the vitreous area adjacent to the posterior field of the eye and cleansing of the retina from all inflammatory infiltration. Leaving of the vitreous cortex enables persistence of the inflammatory components, from bacteria to toxins and inflammatory factors, which could toxically influence the retina even after PPV. Only in the area of the base of the vitreous area, where adherence is considerably stronger, is it necessary to select very carefully with regard to the inflammation-altered and fragile retina. The use of new surgical technologies, such as biological observation matrix (BIOM), colouring of the vitreous area and membranes (triamcinolon, membrane blue, indocyanine green) or the use of an endocamera substantially improves the precision of perfect removal of the inflammation-altered base of the vitreous area (Kuhn 2005, De Smet 2005).It has been demonstrated that visual rehabilitation after timely and complete vitrectomy with removal of all inflammatory material is considerably faster, and the risk of an iatrogenic crack and detachment of the retina is smaller upon use of modern display and surgical procedures (Kuhn 2005, Becker 2007, Lemley 2007, Ng 2005). Treatment of chronic postoperative endophthalmitis is analogous as with acute endophthalmitis. However, certain factors may modify the treatment procedure. Depending on the course of the endophthalmitis and the affliction of the visual functions, it is possible to consider first of all diagnostic sampling of material for processing in bacteriology, cytology and according to the result initially intravitreal application of antibiotics (Maguire 2008, Kuhn 2005). Only upon failure of a minimal surgical procedure is indication for PPV subsequently stipulated.

Clinical recommendations

It is necessary to consider acute endophthalmitis to represent an urgent operation, to be performed immediately after determination of the diagnosis. As soon as indication for operation is stipulated on the basis of a clinical examination, ultrasound finding and anamnesis, the operation should be performed without delay, immediately after the performance of the essential preoperative preparation (preoperative internal examination, preparation of surgical team, securing of antibiotic treatment).

Open injuries – penetrating, perforating injuries to eye (with or without foreign body), rupture of eye

This is understood to mean penetrating eye injury with or without a foreign body, with or without prolapse of the intraocular tissues, also rupture or laceration of the wall of the eye after injury to the eye. It has been demonstrated that a time delay (more than 12 hours from the injury) of the primary treatment substantially increases the risk of inflammatory complications (endophthalmitis) and extends the time for healing of the injury. Primary treatment of the eye injury must be considered to be an urgent and pressing procedure (ideally to be performed within 6 hours and within a maximum of 12 from the injury.) The timeliness of the procedure improves not only the

prospects of preservation of good visual functions but also the possibility of resolving secondary reconstructions of the eye within a later period. The primary procedure includes treatment (suture) of the penetrating or perforating eye wound or rupture of the eye, cutting of the prolapsing and non-functional eye tissues. It may also involve the removal of the intraocular body by an external approach or via PPV. Primary treatment includes intraocular or overall antibiotic treatment. Secondary procedure includes removal of the foreign body, reconstruction of the anterior and posterior segment of the eye and resolution of complications ensuing from the injury itself or from the primary treatment. The secondary procedure is not an urgent operation and its indication ensues exclusively from the development or post-injury complications of the eye.

Pathobiology of healing of wound

Injury to the eye leads to inflammatory infiltration and impairment of the haemato-ocular barrier with an expression of chemokines, inflammatory cytokines and growth factors which subsequently affect the activity of RPE cells, fibroblasts and glial cells. These cells proliferate, migrate and to a considerable degree share in the formation of preretinal membranes. They are distinguished by a high capability of contractility, which in the process of maturing of the membranes creates tractional forces not only in the membrane itself but also towards the retina. If these tractional forces overpower the normal adhesive bond between the neuroretina and RPE, tractional retinal detachment occurs (Ryan). The standard course of healing and biochemical processes have been observed in a range of studies (21-30 from Ryan). Of fundamental significance for the development of complications, above all the development of proliferative vitreoretinopathy (PVR) and detachment of the retina is the time sequence of the processes of cellular infiltration, the accumulation of extracellular collagen and the formation of membranes. During the 2nd week following the injury, an increased contractility of the collagen fibres, blood coagulations and an ablation of the cortical vitreous area takes place. Between 2 and 4 weeks after the injury, fibrous proliferation of the damaged wall of the eye occurs, with the formation of blood coagulations. The development of epiretinal membranes was observed from the 4th to the 15th week following the injury. Due to the influence of contraction of the membranes and glio-vascular proliferations, detachment of the retina occurs. This usually occurs between the 6th and 11th week (Ryan). A range of experiments have demonstrated that the presence of blood in the vitreous area and in the membranes increases the risk of PVR and detachment of the retina (24, 30 from Ryan). The development of PVR and the development of endophthalmitis are the main factors connected with the failure of treatment and primarily unfavourable prognosis following perforating injuries to the eye (10 from Ryan). The frequency of development of PVR after an open injury to the eye fluctuates according to the type of injury, 43% after a perforating injury, 21% after a rupture of the eye, 15% after a penetrating injury and 11% upon the presence of a foreign intraocular body. There is an increased risk of the development of PVR in the case of preoperative vision of worse than 5/200, concurrent injury to the anterior and posterior segment, a wound longer than 10 mm, prolapse of intraocular tissues, upon concurrent detachment of the retina, choroidal haemorrhage and intraocular inflammation (Kuhn).

The course of healing of the wound may be modified by a range of factors, the most serious of which include the development of bacterial endophthalmitis and the presence of a foreign intraocular body (111 from Ryan). Bacterial endophthalmitis after a penetrating eye injury occurs in 2-48% of cases (111 from Ryan). A risk factor in the development of endophthalmitis is the presence of a foreign intraocular body and a delay of closure of the wound (111, 113, 114, 115 from Ryan). Deferral of extraction of an infected foreign intraocular body or delay of closure of a penetrating wound for longer than 24 hours is connected to a high risk of endophthalmitis (116 from Ryan). It is necessary to consider all biological materials, i.e. “cold bodies” and bodies with a risk of soil pollution, to represent an infected foreign intraocular body.

The most serious cause of poor vision in the case of a foreign intraocular body is direct injury to the retina by a foreign body, post-injury PVR with subsequent detachment of the retina or siderosis. Predictive factors of a poor postoperative result are injuries with preoperative retinal detachment, scleral or sclerocorneal entry wound and size of the foreign intraocular body (112-114 from Ryan). An entry wound longer than 22 mm gives a very negative prognosis.

Ocular siderosis is caused by released trivalent iron ions. It may develop within a few days after the injury, but often appears after an interval of several years. Its development depends on the character and composition of the foreign body, its localisation and encapsulation. Due to the influence of the toxic action of the iron ions on the retina a deterioration of the b wave takes place on the electroretinogram. The deterioration of the b wave to 40% may be reversible after the extraction of the foreign body (121 from Ryan).

Designation of treatment strategy

The introduction of modern surgical instruments and surgical techniques has dramatically improved the prognosis for open and closed eye injuries. From the prospective studies of the 1970s and 80s it ensues that only 5% of patients attained a postoperative vision of better than 5/200 after an open eye injury (11 from Ryan). At present almost 55% of patients have hope of postoperative vision better than 5/200 and more than 1/3 of them can hope for vision better than 6/12 (8,12 from Ryan). Although it ensues from the statistics that the functional results following an operation on an eye injury are fundamentally better today than in previous years, eye trauma nevertheless remains the main cause of monocular loss of vision (3 from Ryan). Designation of a strategy upon treatment of an eye injury ensues from the internationally recognised BETT (Birmingham Eye Trauma Terminology) classification of injuries from 2008 (Kuhn). For the requirements of the standard of acute vitreoretinal care, the BETT classification is suitable amongst other factors mainly due to the timing of the individual measures of the primary treatment of the injury and designation of the subsequent reconstruction of the eye.

1. Closed injuries – contusions – lamellar lacerations
2. Open injuries – lacerations – rupture
   - Penetration
   - Foreign intraocular bodies
   - Perforation

Ad 1) Closed eye injuries (without breach of the wall of the eye) require an immediate operation intervention in entirely exceptional cases. They almost always provide sufficient room for determination of the diagnosis and stipulation of the treatment procedure. In the case of ambiguities they also provide sufficient time for consultation of the workplace of the higher type. In the case of closed injuries to the eye, inflammatory complications do not ensue

and the risk of development of PVR is minimal in the early post-injury period.
Ad 2) Open injuries (breach of wall of eye) – decision on when to operate is urgent. Timing of the operation is of fundamental importance for the development of visual functions in the postoperative period, and depends on the scope of the injury, localisation of the wound, presence of prolapsing intraocular tissues, presence of foreign intraocular body, bacterial contamination of the wound and also the general condition of the patient. The rule for treatment of open eye injuries is closure of the wound within the shortest possible time after the injury. Deferral of the operation within the range of a few hours mostly does not have an influence on the resulting visual functions, nevertheless performance of the operation within the shortest possible time by qualified healthcare personnel is recommended according to the conditions and availability of the ophthalmological facility. Of the various injury conditions there are only a few where both a primary and secondary operational procedure is highly urgent and should be performed within a highly specialised healthcare facility (VRC) with knowledge of vitreoretinal operations within the space of a few hours. These acute injury conditions include:

- Combined open injuries to the anterior and posterior segment of eye (zones II and III according to BETT) or with choroidal expulsive haemorrhage and prolapsed of intraocular tissues.
- Threatening risk of endophthalmitis – developing endophthalmitis, soil or biological contamination of wound or foreign body.

Whilst open injuries to the anterior segment of the eye (zone I) require conditions of the personnel and technical equipment for surgery of the anterior segment, open injuries in zones II and III require highly specialised personnel and technical equipment for surgery of the posterior segment. The operation procedure should also be performed only by a doctor with experience of similar types of operations, equipped with competences for this surgery.

Clinical recommendations for treatment of eye injuries

Primary treatment of eye injuries requires an urgent decision and stipulation of the treatment strategy. Primary suture of the wound should take place within the shortest possible time after determination of the diagnosis, and no later than 12 hours afterwards, in a facility equipped for the treatment of injury conditions with experience of similar types of operations. As a rule, closed eye injuries do not require an immediate surgical solution and provide sufficient room for diagnosis and stipulation of the treatment procedure. Open injuries require an urgent operation solution, which resides in closure of the wound within the shortest possible time following the injury. Treatment in ophthalmological facilities with experience of surgery on the anterior segment is sufficient for treatment of open injuries in zone I, whereas a specialised medical team and technical and personnel facilities, with experience of surgery on the posterior segment is required for zones II and III. The various injury conditions include states in which treatment should take place immediately within the space of a few hours in vitreoretinal centres (VRC) which are highly specialised in the resolution of severe complications of the posterior segment, no later than 12 hours after the injury. These conditions are understood to cover:

- Combined open injuries to the anterior and posterior segment of the eye (zones II and III according to BETT), or with choroidal expulsive haemorrhage and prolapse of intraocular tissues.
- Threatening risk of endophthalmitis – developing endophthalmitis, soil or biological contamination of wound or foreign body.

Technical and personnel conditions and requirements are essential for the provision of highly specialised vitreoretinal care of acute vitreoretinal conditions in ophthalmology.

Requirements for technical equipment of vitreoretinal centre (VRC)

- Ophthalmological inpatient facility
- Independent vitreoretinal theatre equipped with 1-2 operating tables
- Operation microscope equipped with inversion system
- Vitrectom for surgery of posterior segment
- Phakoemulsification unit
- Endolaser
- Operating sets with microsurgical instruments for surgery of anterior and posterior segment
- Cryosurgical unit
- Keratoprosthesis
- Requirements for diagnostic equipment
- Funduscamera with option of performing fluorescent angiography
- Digital display systems (OCT, UBM)
- Ultrasound diagnosis (a, b, biometry)
- Direct and indirect ophthalmoscopy including examined contact and contactless lenses
- Requirements for personnel composition
- Minimum of 5 doctors
- Vitreoretinal surgeons with specialised qualification in the field of ophthalmology, with minimum of ten years' experience in the field
- 2 vitreoretinal surgeon with specialise qualification in the field of ophthalmology
- 2 ophthalmologists with specialised qualification in the field of ophthalmology and knowledge of diagnosis and treatment of posterior segment of eye
- Continuous 24-hour availability of surgical team
- Continuous 24-hour availability of anaesthesiological team

Ad 3) Management of specialised vitreoretinal care (general provisions)

a) Characteristics of vitreoretinal workplace

Vitreoretinal centres (VRC) are vitreoretinal workplaces which meet the conditions for granting of status on the basis of a decree of the Ministry of Health.

b) Obligations of sending workplace

After determining the diagnosis of an acute vitreoretinal condition, the ophthalmological workplace shall decide on the treatment procedure. In resolving of the situation it shall consult the available VRC. The sending workplace is obliged to ensure sending of the patient with the acute vitreoretinal condition to the VRC within the shortest possible time following determination of the diagnosis and to select the most efficient means of transport for the condition of health of the patient.

c) Obligations of VRC

VRCs are workplaces with 24 hour availability for provision of acute vitreoretinal care according to the requirements of the ophthalmological workplaces. Patients with an acute VR condition are admitted to the VRC on the basis of sending by an ophthalmologist or ophthalmological workplace following telephone communication or direct contact of the patient, regardless of the ophthalmological area. The VRC is obliged to examine the patient sent with an acute VR condition and to stipulate the best treatment procedure.
After determination of the indication for an operation solution, the VRC is

obliged to perform the operation procedure within the shortest possible time after the conditions have been met to enable the operation procedure (diagnostic examinations, preoperative examinations, technical conditions, general condition of patient). For timing of the surgical solution the VRC respects the general recommendations stated in the chapters of the individual acute VR conditions. Deferral of an operation solution must always be justified in writing in the documentation. If for any reasons the VRC is not capable of performing the operation procedure, it shall ensure an operation solution at another workplace with the status of VRC.

After the performed operation, the VRC shall stipulate the method and location for monitoring of the postoperative condition with regard to the clinical condition and access of the patient to the healthcare facility.

LITERATURE

1. Aaberg T.M Jr, Flynn H.W Jr, Schiffman Jet al. Nosocomial acute-onset endopthalmitis survey. A 10-year review of incidence and outcomes. Opthalmology 1998; 105:1004-10.
2. Ah-Fat F.G, Sharma M.C,Majid M.A et al. Trends in vitreoretinal surgery at the tertiary refferal centre:1987-1996. Br J Opthalmol 1999;83:396-398.
3. Alfaro D.V, Roth D, Ligget P.E. Post-traumatic endopthalmitis: causative organisms, treatment, and prevention. Retina 1994;14:206-211.
4. Bales M.W. Traumatic retinopathy In: Albert D.M, Jakobiec F.A. (eds) Principles and practice of Opthalmology W.B. Saunders: Philadelphia 1994: Vol 2 pp 1029-1031.
5. Bardbury M.J, Landers M.B. Pathogenetic mechanisms of retinal detachment. In:Ryan S.J, Wilkinson CP (eds). Retina Mosby: St. Louis 2001: 1987-1993.
6. Berglin L, Algvere P.V, Seregard S. Photoreceptor decay over time and apoptosis in experimental retinal detachment. Graefes Arch Clin Exp Opthalmol 1997;235: 306-312.
7. Bonet M, Fleury J, Gouenoun S et al. Cryopexy in primary rhegmatogenous retinal detachment: a risk factor for postoperative PVR. Graeves Arch Clin Exp Opthalmol 1996;234:739-743.
8. Brazitikos P.D, D Amico D.J, Tsinopoulos I.T et al. Primary vitrectomy with perfluoro-n-octane use in the treatment of pseudophakicretinal detachments with undetected retinal breaks. Retina 1999;19: 103-109.
9. Brinton G.S,Aaberg T.M, Reeser F.H et al. Surgical results in ocular trauma involving the posterior segment. Am J Opthalmol 1984;93:271-278.
10. Burton T.C, Lambert R.W Jrt. Recovery of visual aquity after retinal detachment involving macula. Trans Am Opthalmol Soc 1982;80:475.
11. Byer N.E. Changes in prognosis of lattice degeneration of the retina. Trans Am Acad Opthalmol Otolaryngol 1974;78: 114-125.
12. Byer N. E. Subclinical retinal detachment resulting from asymptomatic retinal breaks: prognosis for progression and regression. Opthalmology 2001;108:1499-1503.
13. Campochiaro P.A, Jerdan P.A,-Glasser B.M. The extracellular matrix of human retinal pigment epithelial cells in vivo and its synthesis in vitro. Invest Opthalmol Vis Sci 1986;27:1615-1621.
14. Celorio J.M, Pruett R.C. Prevalence of lattice degeneration and its relation to axial length in severe myopia. Am J Opthalmol 1991;111:20-23.
15. Cleary P.E, Ryan S.J. Histology of wound, vitreous, and retina in experimental posterior penetrating eye injury in the rhesus monkey. Am J Opthalmol 1979;88: 221-231.
16. Cooper B.A, Holekamp N.M, Bogigian G et al. Case-control study of endopthalmitis after cataract surgery comparing scleral tunel and corneal wound. Am J Opthalmol 2003;136:300-305.
17. De Juan E Jr, Steinberg P Jr, Michels R.G. Penetrating ocular injuries: types of injuries and visual results. Opthalmology 1983;90:1318-1322.
18. The Eye Disease Case-control Study Group. Risk factors for idipathic rhegmatogenous retina detachment. Am J Epidemiol 1993;137:749-757.
19. Fischer S.K, Lewis G.P. Muller cells and neuronal remodeling in retinal detachment and reattachment and their potential consequences for visual recovery. Vis Res 2003;43:887-897.
20. Ghazi N.G, Green W.R. Pathology and pathogenesis of retinal detachment. Eye 2002;16:411-421.
21. Gingell D, Fornes J.A. Demonstration of intermolecular forces in cell adhesion using a new electrochemical technique. Nature 1975;256: 210-211.
22. Green W.R. Retina In:Spenser W.H (ed) Opthalmic patology: an Atlas and Textbook WE Saunders: Philadelphia 1996 4th edn. Vol 2 pp 667-1313.
23. Green W.R, Sebag J. Vitreoretinal interface In: Ryan S.J, Wilkinson CP (eds) Retina Mosby: St. Louis 2001, 3th edn Vol 3 pp 1882-1960.
24. Gregor Y, Ryan S.J. Combined posterior contusion and penetrating injury in the pig eye. II. Histologal features.Br J Opthalmol 1982;66: 799-804.
25. Gregor Z, Ryan S.J. Complete and core vitrectomies in the treatment of experimental posterior penetating eye injury in the rhesis money. I. Clinical features. Arch Optalmol 1983;101:441-445.
26. Grizzard W.S, Hilton G.F, Hammer M.E et al. A multivariate analysis of anatomic success of retina detachments treated with scleral buckling. Graefes Arch Clin Exp. Opthalmol 1994;232:1.
27. Grossniklaus H.E, Green W.R. Pathologic findings in pathologic mopia. Retina 1992;12:127-133.
28. Gruposso S. S. Visual acuity following surgery for retinal detachment. Arch Opthalmol 1979;93:327.
29. Guerin C.J, Anderson D.H, Fariss R.N et al. Retinal reattachment of the primate macula. Photoreceptor recovery after short-term detachment. Invest Opthalmol Vis Sci 1989;30:1708-1725.
30. Gundri M.F, Davies E.W.G. Recovery of visual aquity after detachment surgery. Am J Opthalmol 1974;77:310.
31. Hageman G.S, Johnson L.V. Structure, composition, , and function of the retinalinterphotoreceptor matrix. In : Osborne N, Chader J, eds. Progres in retinal research. Oxford: Pergamon Press; 1991.
32. Hageman 1995 GS, Marmor M.F, Zao X.Y et al. The interphotoreceptor matrix mediates promate retinal adhesion. Arch Opthalmol

1995;113:655-660.
33. Hageman G.S, Johnson L.V. The cone matrix sheeth: structural, compositional, and functional analyse. Invest Opthalmol Vis Sci 1988;29(supl):108.
34. Hagimura N et al. Optical coherence tomography of the neurosensory retina in rhegmatogenous retinal detachement. Am J Opthalmol 2000;129:186-190.
35. Han D.P, Wisniewski S.R, Wilson L.A et al. Spectrum and susceptibilities of microbiologic isolates in the Endopthalmitis Vitrectomy Study. Am J Opthalmol 1996; 122:1-7.
36. Hartz A.J, Burton T.C, Gottlieb M.S, et al. Outcome and analysis of scheduled versus emergency scleral buckling surgery. Opthalmology 1992;99:1358-1363.
37. Heimann H, Hellmich M, Bornfeld N et al. Scleral buckling versus primary vitrectomy in rhegmatogenous retinal detachment. Graefes Arch Clin Opthalmol 2001;239:565-574.
38. Hisatomi T, Sakamoto T, Murata T et al. Relocalization of apoptosis inducing factor in photoreceptor apoptosis induced by retina detachment in vivo. Am J Pathol 2001;158: 1271-1278.
39. Hollyfield J.G, Varner H, Rayborn M.E et al. Retinal attachment to the pigment epithelium. Retina 1989;9:59-68.
40. Hsu H.T, Ryan S.J. Natural history of penetrating ocular injury with retina laceration in the money. Graefes Arch Clin Exp Optalmol 1986;224:1-6.
41. Chang C.J, Lai W.W, Edward D.P et al. Apoptotic photoreceptor cell death after traumatic retinal detachment in humans. Arch Opthalmol 1995;113:880-886.
42. Cherry P.M.H. Rupture of the globe. Arch Opthalmol 1972;88:498-507.
43. Johnston L.V, Hageman G.S, Blanks M. C. Interphotoreceptor matrix domains ensheeth vertebrate cone photoreceptor cells. Invest Opthalmol Vis Sci 1986;27:129-135.
44. Jonas J.B, Budde W.M. Early versus late removal of retained intraocular foreign bodies. Retina 2000;19:193-197
45. Kaluzny J. Myopia and retina detachment. Pol Med J 1970;9:1544-1549.
46. Kim R, Yao X.Y, Marmor M.F. Oxygen dependency of retina adhesion. Invest Opthalmol Vis Sci 1993;34:2074-2078.
47. Kreissig I. Prognosis of return of macular function after retinal reattachment. Mod Probl Opthalmol. 1977;18:415.
48. Kresloff M.S, Castellarin A.A, Zarvan M.A. Endopthalmitis. Surv Opthalmol 1998;43:193-224.
49. Kroll A.J, Machemer R. Experimental retinal detachment and reattachment in the thesis money. Elektron microscopic comparison of rods and cones. Am J Opthalmol 1969;68:58-77.
50. Kuhn F, Ghini G. Ten years after…. Are the findings of the Endopthalmimitis Vitrectomy Study still relevant today? Graefes Arch Clin Exp Opthalmol 2005; 243:1197-1199.
51. Kuhn F, Morris R, Witherspoon CD,et al. Standardized classification of ocular trauma. Ophthalmology 1996;103:240-243.
52. Kusaka S, Toshino A, Ohashi Y et al. Long-term visual recovery after scleral buckling in macular--off retinal detachments. Jpn J Opthalmol 1998;42:218-222.
53. Lemley C.A, Han D.P. Endopthalmitis: a review of current evaluation and management. Retina 2007;27:662-680.
54. Lewis G.P, Sehti C.S, Lindberg K.A et al. Experimental retinal reattachment: new perspective. Mol Neurobiol 2003;28:159-175.
55. Machemer R. The importance of fluid absoption, traction, intraocular currents, and chorioretinal scars in the theory of rhegmatogenous retinal detachments. Am J Opthalmol. 1984;98:681-693.
56. Machemer R. Proliferative vitreoretinopathy (PVR): a personál approach to its pathogenesis and treatment. Proctor lecture. Invest Opthalmol Vis Sci 1988;29:1771-1783.
57. Marmor M.F. Mechanisms of normal retinal adhesion.In Ryan S.J, Wilkinson CP. Retina Mosby: St Louis 2001: 1849-1869.
58. Marmor M.F. Retinal detachment from hyperosmotic intravitreal injection. Incest Opthalmol Vis Sci 1979;18:1237-1244.
59. Mester V, Kuhn F. Intraocular foreign bodies. Opthalmol Clin North Am 2002;235-242.
60. McCray E, Rampell N, Solomon S.L et all. Outbreak of Candida parapsilosis endopthalmitis after cataract extraction and intraocular lens implantation. J Clin Microbiol 1986;24:625-628.
61. Meredith T.A, Trabelsi A, Miller M.J et al. Spontaneous sterilization of experimental Staphylococcus epidermidis endopthalmitis. Invest Opthalmol Vis Sci 1990;31:181-186.
62. Miki D, Hida T, Hotta K et al. Comparison of scleral buckling and vitrectomy for retinal detachment resulting from flap tears in superior quadrants. Jap J Opthalmol 2001;45:187-191.
63. Miller D, Flynn P.M, Scott I.U et al. In vitro fluoroquinolone resistance in Staphylococcal endopthalmitis. Arch Opthalmol 2005;124:479-483.
64. Nagaki Y, Hayasaka S, Kadoi C et al. Bacterial endophtalmitis after small-incision cataracta surgery. Effect of incision placement and intraocular lens type. J Cataract Refract Surg 2003;29:20-26.
65. Ng E.W,Baker A.S,D Amico D.J. Postoperative endopthalmitis: risk factor and prophylaxis. Int Opthalmol Clin 1996;36:109-130.
66. Norregaard J.C, Thoning H, Anderson T.F et al. Risk of retinal detachment following cataract extraction: results from the international cataract surgery outcomes study. Br J Opthalmol 1996;80:689-6931997
67. Okun E. Gross and microscopic patology in autopsy eyes.III. Retinal breaks without detachment. Am J Opthalmol 1961;51:369-391.
68. Oshima Y, Sakamoto T, Hisatomi T et al. Gene transfer of solubile TGF-beta type II receptor inhibits experimental proliferative vitreoretinopathy. Gene Ther 2002; 9:1214-1220.
69. Parish C.M, O Day D.M. Traumatic endopthalmitis. Int Opthalmol Clin 1987;27:112-119.
70. Pieramici D.J, Mac Cumber M.W et al. Open-globe injury: update on type of injuries and visual results. Opthalmology1996; 103:1798-1803.
71. Pournaras C.J, Donati G, Sekkat L et al. Pseudophakic retinal detachment: treatment by vitrectomy and scleral buckling. Pilot study. J Fr Opthalmol 2000;20:1006-1011.
72. Rachal W.F, Burton T.C. Changing concepts of failure after retinal detachment surgery. Arch Opthalmol 1979;97:480.
73. Ross W.H, Stockl F.A. Visual recovery after retinal detachment. Curr Opin Opthalmol 2000;11:191-194.
74. Ross W.H, Kozy D.W. Visual outcome in macula-off rhegmatoge-

nous retinal detachments.Opthalmology 1988;105:2149-2153.
75. Ross W.H. Visual recovery after maculaoff retinal detachement. Eye 2002;16: 440-446.
76. Rousel T.J, Cullbertson W.W, Jaffe N.S. Chronic postoperative endopthalmitis associated with propionibacterium acnes. Arch Opthalmol 1987;105:1199-1201.
77. Ryan SJ, Quidelines in the management of penetrating ocular trauma with emphasis on the role of timing of pars plana vitrectomy. Int Opthalmol 1979;1:105-108.
78. Samson M, Foster C.S. Chronic postoperative endopthalmitis. Int Opthalmol 2000;40:57-67
79. Scott J.D. Future perspectives in primary retinal detachment repair. Eye 2002;16: 349-352.
80. Somani S, Grimbaum A, Slomovic A.R. Postoperative endopthalmitis: incidence, predisponing surgery, clinical course and outcome. Can J Opthalmol 1997;32:303-310.
81. Speaker M.G, Milch F.A, Shah M.K. Role of external bacterial flora in the pathogenesis of acute postoperative endopthalmitis. Opthalmology 1991;98:639-649.
82. Steinberg R.H. Research update: report from a worshop on cell biology of retinal detachement. Exp Eye Res 1986;43:695-706.
83. Taban M, Behrens A, Rylander M. Acute endopthalmitis folowing cataract surgery: a systematic review of the literature. Arch Opthalmol 2005;123:613-620.
84. Tani P, Robertson D, Langworthy B.A. Rhegmatogenous retinal detachment without macular involvement treated with scleral buckling. Am J Opthalmol 1980;90: 503-508.
85. Tani P, Robertson D.M, Langworthy A. Prognosis for central vision and anatomic reattachment in rhegmatogenous reinal detachment with macula detached. Am J Opthalmol 1982;92:611-616.
86. Thompson WS, Rubsamen PE, FlynnJr HW et al. Endophatalmitis after penetrating trauma. Risk factors and visual outcomes. Opthalmology 1995;102:1696-1701.
87. Tielsch J.m, Legro M.W, Cassard S.D et al. Risk factors for retina detachment after cataract surgery. A population-based case-control study. Opthalmology 1996;103:1537-1545.
88. Yao X.Y, Hageman G.S, Marmor M.F. Retinal adhesivenes in money, Invest Opthalmol Vis Sci 1994;35:744-748.
89. Verbraeken H, Van Leathem. Treatment of endopthalmitis with and whitout pars plana vitrectomy. Opthalmologica 1985; 191:1-3.
90. Wani V.K, Al-Ajmi M, Thalib L et al. Vitrectomy for posterior segment intraocular foreign bodies, visual results and prognostic factors. Retina 2003;23:654-660.
91. Werner L, Sher J.H, Tailor J.R et al. Toxic anterior segment syndrom and possible association with ointment in the anterior chamber following cataract surgery. J Cataract Refract Surg 2006;32:227-235.
92. Wykoff C.C, Smiddy W.W, Mathen T. et al. Fovea-sparing retinal detachments not involving the macula. Am J Opthalmol 2010;150: 205-210.
93. Zambrano W, Flyn H.W Jr, Pfluger S.C et al. Management options for Propnonibacterium acnes endopthalmitis Opthalmology 1989;96:1100-1105.
94. Zimmermann P.L, Mamalis N, Alder J.B. Chronic nocardia asteroides endopthalmitis after extracapsular cataract extraction. Arch Opthalmol 1993;111:837-840.