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Post-traumatic endophthalmitis: causative organisms and visual outcome

A.M. ABU EL-ASRAR, S. A. AL-AMRO, A.A. AL-MOSALLAM, S. AL-OBEIDAN

Department of Ophthalmology, College of Medicine, King Saud University, Riyadh - Saudi Arabia

ABSTRACT: Purpose. *Post-traumatic endophthalmitis makes up a distinct subset of intraocular infections. The purpose of the present study was to identify the causative organisms and record the visual outcome after infectious endophthalmitis in eyes with penetrating trauma.*
Methods. *We reviewed 18 consecutive cases of culture-positive endophthalmitis that developed after penetrating ocular trauma. All cases were treated with pars plana vitrectomy and intravenous and intraocular antibiotics.*
Results. *The 15 males and 3 females ranged in age from 4 to 43 years (mean 25.1 ± 11 years). Nine (50%) had intraocular foreign bodies. A single species was isolated in 16 cases, and multiple organisms in two.* Staphylococcus epidermidis *and gram-negative organisms were the most frequent and were cultured either alone or in association with other organisms in respectively five (27.7%) and four cases (22.2%).* Clostridium perfringens *was isolated in three cases (16.6%).* Bacillus *was not found as a cause of endophthalmitis. Final visual acuity was better than 20/400 in eight cases (44%). In five cases (27.7%), the eye was saved but visual acuity was counting fingers. Two eyes (11%) had no light perception. The remaining three eyes (16.6%) were enucleated or eviscerated.* Clostridium perfringens *was isolated from two eyes and* Aspergillus niger *from one. Postoperative retinal detachment developed in four eyes, which were successfully operated.*
Conclusions. *Organisms isolated in this series were similar to those in previous reports of post-traumatic endophthalmitis from other parts of the world, except that the frequency of* Clostridium perfringens *isolation was high and no* Bacillus *species were cultured. In view of its devastating outcome, post-traumatic endophthalmitis must be treated promptly with vitrectomy and intravitreal antibiotics. (Eur J Ophthalmol 1999; 9: 21-31)*

KEY WORDS: Penetrating ocular trauma, Endophthalmitis, Clostridium perfringens, *Intraocular foreign body,* Staphylococcus epidermidis

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INTRODUCTION

Post-traumatic endophthalmitis is a catastrophic complication of penetrating ocular trauma. It constitutes a distinct group of intraocular infections in which the precipitating injury, associated inflammation, and microbiology all play a role in the final visual outcome. A different microbiological spectrum distinguishes this group from endophthalmitis observed in other clinical settings (1-8).

No data are available about the microbiological spectrum of post-traumatic endophthalmitis in Saudi Arabia. Here we report our experience in the management of 18 consecutive cases of culture-positive post-traumatic endophthalmitis to identify the bacteriological spectrum and estabilish the visual prognosis after penetrating trauma.

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MATERIALS AND METHODS

We reviewed the medical records of 27 consecutive cases of suspected post-traumatic endophthalmitis seen at our institution between 1993 and 1998. For each case, we obtained patient's age, sex, type of injury, initial visual acuity, vitreous culture results, treatment regimen, and final visual acuity. All patients underwent a thorough eye examination that included x-ray of the orbit and B-scan ultrasonography. In cases with suspected intraocular foreign bodies, a computed tomographic scan was ordered.

Three cases had to be enucleated or eviscerated after primary repair because of severe intraocular inflammation. Primary pars plana vitrectomy was performed in 24 cases in conjunction with repair of corneal wounds for patients who had not had primary repair, and removal of foreign bodies using intraocular foreign body forceps. Vitreous samples were collected undiluted by manual suction into a syringe through the aspiration line of the vitrectome, before opening the infusion line, followed by a core vitrectomy which was continued until retinal view was obtained. The vitrectomy fluid from the cassette was centrifuged to produce a concentrated pellet. Specimens were processed for direct smears treated with Gram and Giemsa stain.

Samples were inoculated into blood agar (aerobic and anaerobic), choclate agar, and thioglycolate broth, all incubated at 37°C. In addition, room temperature cultures on Sabouraud's agar without cyclohexamide were used to grow fungi. A positive culture was defined as growth of the same organism on two or more media, or confluent growth on at least one solid media.

Intravitreal antibiotics were gentamicin 0.2 mg or amikacin 0.4 mg and vancomycin 1 mg. Recently ceftazidime 2.25 mg was used to cover gram-negative bacteria. In cases of suspected fungal endophthalmitis based on the clinical appearance and presenting history, amphotericin B 10 µg was given intravitreally. Systemic, subconjunctival, and topical antibiotics were administered in addition to the intravitreal drugs. Subconjunctival (triamcinolone, 40 mg), systemic, and topical steroids were also given.

The following case presentations illustrate unique features of post-traumatic endophthalmitis that we felt are worth stressing.

Case Reports

Case 2

A 35-year-old male presented to the emergency room complaining of sudden loss of vision and pain in the right eye of one day's duration. Two days before presentation, he had sustained a penetrating trauma to his right eye while hammering on a piece of metal. The patient was found to have light perception in the right eye and visual acuity 20/30 in the left eye. Intraocular pressure was 26 mmHg in the right eye and 10 mmHg in the left. The right eye showed mild swelling of the eyelids. The conjunctiva was injected, with moderate chemosis. The cornea showed edema and a 3-mm limbal laceration at 10 o'clock. Large white keratitic precipitates were noted. The anterior chamber was formed and filled with fibrinous exudate and a 2 mm hypopyon. The lens showed localized cataract and the red reflex was absent. The left eye was normal.

X-ray of the right orbit showed an opaque foreign body. Computed tomographic scan indicated an intravitreal metallic foreign body. Ultrasonography showed dense vitreous opacities with multiple strands and membranes, diffuse thickening of the retinal-choroid layer, and the retina was attached.

The patient was immediately admitted to hospital and intravenous gentamicin 80 mg was started every 8 hours with cefazolin 1 g every 6 hours. The patient underwent repair of the corneal laceration, pars plana lensectomy and clearing of the fibrinous exudate in the anterior chamber. A concentrated vitreous biopsy specimen was obtained, followed by a core vitrectomy which was continued until retinal view was obtained. The retina had multiple areas of localized white infiltrates and extensive perivascular sheathing. The foreign body was removed carefully using an intraocular foreign body forceps.

Vancomycin 1 mg in 0.1 ml and gentamicin 0.2 mg in 0.1 ml were given intravitreally. At the end of the procedure, subconjunctival injections of vancomycin 25 mg, gentamicin 20 mg, and triamcinolone 40 mg were given.

Microbial cultures showed heavy growth of gram-positive bacilli in anaerobic conditions, characteristic of *Clostridium perfringens*. The organism was sensitive to penicillin, erythromycin, clindamycin, chloramphenicol, cefazolin, and metronidazole. Intra-

venous gentamicin was discontinued and the patient was maintained on intravenous cefazolin.

Three days after surgery, the patient was given another intravitreal injection of cefazolin 2.25 mg in 0.1 ml. Seven days after the first procedure, the media became clear and a retinal detachment was noted temporally due to two flap breaks in the inferotemporal quadrant. Two days later, we performed a scleral buckling procedure, pars plana vitrectomy to remove the remaining vitreous debris, and fluid/air exchange. The procedure was followed by flattening of the retina. Three months later, examination showed a flat attached retina and visual acuity of 20/100. Intraocular pressure was 12 mmHg with a clear anterior chamber.

Case 10

A 24-year-old male was injured in the left eye by a wooden stick. On presentation to the emergency room 5 hours later, he had a corneal laceration with iris incarceration, shallow anterior chamber, and total cataract. Visual acuity was hand motions. The other eye was normal. No foreign body could be detected by x-ray in the left orbit. Intravenous gentamicin and vancomycin were started. A few hours later, the patient underwent primary wound repair combined with sampling from the injury site for microbiological analysis. Marked anterior chamber reaction was noted 24 hours after primary repair with 4+ cells. Ultrasonography showed dense vitreous opacities with multiple strands and membranes, diffuse thickening of the retina-choroid layer, and the retina was attached, confirming the diagnosis of endophthalmitis. The patient underwent pars plana lensectomy and diagnostic and therapeutic pars plana vitrectomy, followed by intravitreal injection of amikacin 0.4 mg in 0.1 ml and vancomycin 1 mg in 0.1 ml, and subconjunctival injection of vancomycin, amikacin, and triamcinolone. Gram stain of the vitreous biopsy showed Gram-positive cocci. Microbial cultures showed *Streptococcus pneumoniae*.

One month later, the inflammation had gradually subsided and the patient's vision in this eye improved to 20/60. Two months postoperatively routine follow-up retinal examination showed a completely detached mobile residual peripheral vitreous cortex and an inferotemporal 100° giant retinal tear at the ora serrata with a raised anterior flap from which the vitreous remnant was suspended. There was slight lifting of the posterior flap, but the retina was otherwise flat. Prophylactic 360° postoral laser photocoagulation was performed. One year later, the retina was entirely attached posterior to the photocoagulation scars and the patient's vision in this eye had improved to 20/50.

Case 11

A 43-year-old man had sustained penetrating trauma to his right eye caused by a metallic foreign body while hammering on a piece of metal four days before referral. On initial examination, visual acuity was 20/100 in the right eye and 20/25 in the left. Intraocular pressure was 18 mmHg in both eyes. Slit-lamp biomicroscopic examination showed a 2-mm long, vertically oriented, self-sealed, full-thickness corneal laceration adjacent to the limbus, at the 6 o'clock meridian with iris incarceration. The anterior chamber was deep and showed 4+ cells and a fibrinoid reaction. The lens showed localized cataract. Ophthalmoscopy disclosed a metallic foreign body embedded in the retina inferiorly at the equator, mild inferior vitreous hemorrhage, and mild vitreous cellular reaction. The retina was attached, although fundus details were difficult to see because of the anterior segment changes and inferior vitreous hemorrhage.

The patient was admitted to hospital and started on intravenous gentamicin and vancomycin. One day later, he underwent repair of the corneal laceration, pars plana lensectomy-vitrectomy and intraocular foreign body removal. Intraoperative examination showed dense white vitritis around the foreign body, multiple areas of retinal opacification, and definite diffuse perivascular sheathing of the retinal vessels suggestive of endophthalmitis.

After intraocular cultures were obtained, intravitreal vancomycin 1 mg in 0.1 ml and ceftazidime 2.25 mg in 0.1 ml were given. At the conclusion of the procedure, subconjunctival injections of vancomycin, gentamicin, and triamcinolone were given. Postoperatively, the patient was treated with intravenous gentamicin, vancomycin and oral prednisone (60 mg/day). Vitreous cultures grew *Staphylococcus epidermidis*.

Four months postoperatively, the inflammation had gradually subsided and the best corrected visual acuity was 20/60 in the right eye.

RESULTS

In 18 cases, the clinical suspicion of endophthalmitis was confirmed by positive intraocular cultures. These cases form the basis of this report. There were 15 men and three women with a mean age of 25.1 ± 11 years (range 4-43 years) (Tab. I). The mean interval from injury to treatment for suspected endophthalmitis was 10.3 ± 19.8 days (range 2 days - 3 months). Nine eyes (50%) had intraocular foreign bodies. The range of follow-up was three months to one year.

Surgical repair of the corneal laceration was done before presentation to our institute in six eyes (Tab. I; Cases 4, 5, 6, 8, 16, 18). The foreign body had not been removed during this prior surgery; the time from repair of the corneal laceration to treatment was respectively 36 hours, 9 days, 3 days, 7 days, 40 hours and 7 days. Corneal wounds were repaired in conjunction with pars plana vitrectomy and removal of intraocular foreign bodies in eight cases (Tab. I; Cases 1, 2, 3, 11, 12, 13, 15 and 17). The apparently self-sealed corneal lacerations leaked during pars plana vitrectomy and required suturing. The self-sealed corneal laceration did not require repair in patient 7. These 15 eyes had signs of endophthalmitis at the initial evaluation at our institute. The corneal laceration was surgically repaired at our insitute in three eyes (Tab. I; Cases 9, 10 and 14). These patients were given prophylactic broad-spectrum intravenous antibiotics and had primary repair promptly after their presentation. None of these eyes presented with clinical signs of endophthalmitis and signs of infection were noted respectively three months, one day and two days, after repair of the penetrating injury. Prompt treatment for suspected endophthalmitis was started within a few hours.

A single species was isolated in 16 cases, and multiple organisms were identified in two cases (Tab. II). *Staphylococcus epidermidis* (5) and gram-negative organisms (5) were the most frequent, followed by *Clostridium perfringens, Streptococcus* sp, *Corynebacterium* sp, fungi and *Staphylococcus aureus*. All *Clostridium perfringens* and *Staphylococcus epidermidis* infections were in the group with intraocular foreign bodies.

Eight of the 18 culture-positive eyes (44%) achieved visual acuity better than 20/400 (Tab. I). Another five eyes (27.7%) were salvaged, but visual acuity was only counting fingers. Of the two eyes with a final visual acuity of no light perception, one developed combined central retinal artery and central retinal vein occlusions after the initial pars plana vitrectomy and one had had no light perception at presentation. Three eyes had to be enucleated or eviscerated after primary repair because of very severe intraocular inflammation with a cloudy cornea. The infection did not respond to intravitreal antibiotics or antifungal agents. The organisms isolated were *Clostridium perfringens* in two eyes (Tab. I; Cases 4 and 16) and *Aspergillus niger* in one (Tab. I; Case 9). Eyes with negative cultures had better final visual acuities than eyes with positive cultures. Five (55%) of nine eyes with negative cultures had final visual acuities of 20/200 or better. The other four (45%) were salvaged, but visual acuity was only counting fingers.

The retina was attached at the initial pars plana vitrectomy in 15 patients. Retinal detachment developed in four eyes during the postoperative course which was not associated with phthisis bulbi. These patients had successful retinal reattachment surgery (Tab. I; Cases 2, 3, 12, and 14).

DISCUSSION

The microbiology of post-traumatic endophthalmitis is distinct from exogenous endophthalmitis observed in other clinical settings. *Staphylococcus epidermidis* and gram-negative organisms were the most frequent isolates in our series. *Staphylococcus epidermidis* was cultured either alone or with other organisms in 27.7% of cases. This frequency was the same as in previous studies of post-traumatic endophthalmitis (1-8) (Tab. III). *Staphylococcus epidermidis* endophthalmitis after trauma, however, was less frequent than after operation. Recently, the Endophthalmitis Vitrectomy Study (EVS) (9) reported that coagulase-negative *staphylococci*, predominantly *Staphylococcus epidermidis*, was the most commonly isolated organism, accounting for 70% of the isolates in endophthalmitis after cataract-related surgery. The majority of cases are attributable to bacteria colonizing the patient, particularly the eyelid margin and conjunctiva, that enter the eye intraoperatively (10).

In the present study, all Staphylococcus epidermidis infections occurred in eyes with intraocular foreign bodies. Coagulase-negative *staphylococci*, once

attached to a polymer surface, adhere strongly and become embedded in an extracellular mucoid glycocalyx or slime which protects the embedded bacterial cells against the host's immune response and antibiotic therapy (11). *Staphylococcus epidermidis* adherence to intraocular foreign bodies may be an important factor in the pathogenesis of infectious endophthalmitis after penetrating injuries with retained intraocular foreign bodies, and might explain the localized dense white vitritis around the intravitreal foreign body in case 11.

Gram-negative organisms were isolated with the same frequency in this series as in previous studies of post-traumatic endophthalmitis (Tab. III). This frequency was higher than in endophthalmitis after cataract-related surgery (9). For reasons which remain unclear, *Bacillus* did not occur as a cause of post-traumatic endophthalmitis in this series. *Bacillus*, one of the most destructive bacteria in the eye (12), was cultured either alone or with other organisms in 24% of cases in other reports of post-traumatic endophthalmitis (1-8). *Bacillus* infections are particularly likely if there has been soil contamination of the wound. *Bacillus* species were isolated in 46% of cases of rural endophthalmitis (13). The lack of *Bacillus* organisms in this series might possibly be related to local environmental factors of high temperature and dryness on *Bacillus* spores. *Bacillus subtilis* spores manifest indications of DNA damage when kept in an extremely dry environment, leading to lethal and mutagenic consequences (14). Xue and Nicholson (15) found that at increasing solar UV wavelengths, *Bacillus subtilis* spores were inactivated either by DNA damage, or damage to photosensitive molecules other than DNA, or both.

In our series, *Clostridium perfringens* was isolated in 16.6% of cases. This frequency is higher than the pooled data from other series of post-traumatic endophthalmitis in other areas (2.3%, Tab. III). Boldt et al (13), in rural post-traumatic endophthalmitis isolated *Clostridium perfringens* in one of 24 patients. In our series, all *Clostridium perfringens* infections were associated with a retained intraocular foreign body.

The high incidence of *Clostridium perfringens* in our series is very disturbing. This gram-positive anaerobic bacillus found in soil and bowel flora may cause gas gangrene after penetrating trauma. Panophthalmitis due to *Clostridium perfringens* is seldom observed. The infection is invariably exogenous following a perforating wound of the globe, usually with a retained intraocular foreign body (16). Duke-Elder and Perkins (17) presented the following salient clinical findings: rapid development of a fulminating panophthalmitis, severe pain, early rise of ocular tension, the appearance of blood or a thin cofee-colored discharge, the eventual formation of gas bubbles in the anterior chamber, and the rapid development of total amaurosis. The rapid loss of light perception is presumably due to the effect of toxins liberated by the organisms, leading to the damage of the retinal tissue. In the majority of cases infection progressed despite systemic, subconjunctival, and intravitreal antibiotic therapy. The fulminant picture of clostridial endophthalmitis seen in cases 4 and 16 has been well described. Most cases required evisceration or enucleation for control of the infection (16-19). Early diagnosis and treatment is important because vision may be salvaged with early intervention. Patient 2 was successfully treated with pars plana vitrectomy, removal of the intraocular foreign body and intravitreal antibiotics. Visual acuity improved from light perception to 20/100. Early vitrectomy and vitreous lavage reduced the size of the inoculum, removing the potent toxins liberated by the organisms, and irrigating the vitreous cavity with oxygenated fluid. Any penetrating eye injury with soil-contaminated foreign bodies should be regarded as being at high risk for clostridial infection in Saudi Arabia, and should be treated promptly by early vitrectomy and selective use of intravitreal antibiotics.

Several criteria must be considered in deciding which eyes require pars plana vitrectomy for post-traumatic endophthalmitis. Our clinical impression is consistent with other recommendations (2, 3, 7, 20-22) that patients with relatively mild inflammation (fundus reflex is still present) are initially treated with intravitreal antibiotics after aqueous and vitreous samples are obtained. If there is deterioration after 24 to 48 hours despite intravitreal antibiotics, a pars plana vitrectomy is done. Therapeutic pars plana vitrectomy is recommended in any of the following situations: 1) extensive vitreous abscess precluding visualization of the retina; 2) marked vitreous involvement noted on ultrasound A or B scan; 3) presence of an intraocular foreign body; 4) a virulent organism is cultured from anterior chamber or vitreous aspirate (unless patient is improving); 5) suspected fungal infections; and

TABLE I - DESCRIPTION OF CASES

Case No.	Age,yr/ Sex	Type of trauma	Time from trauma to treatment	Organism	Initial visual acuity	Visual outcome	Comment
1	26M	CL, IOFB	2 days	*Staphylococcus epidermidis, Moraxella* sp	HM	NLP	Postoperatively developed combined CRAO and CRVO
2	35M	CL,IOFB	2 days	*Clostridium perfringens*	LP	20/100	Postoperatively developed retinal detachment that was repaired
3	24M	CL,IOFB	3 days	*Staphylococcus epidermidis*	LP	CF	Postoperatively developed retinal detachment that was repaired
4	21M	CL,IOFB	2 days	*Clostridium perfringens*	LP	eviscerated	Panophthalmitis and orbital cellulitis with marked proptosis and restricted eye movements
5	6F	CL	11 days	*Pseudomonas aeruginosa*	NLP	NLP	
6	33M	CL,IOFB	5 days	*Coeryne-bacterium* sp	HM	20/200	
7	32M	Tree branch self-sealed CL	3weeks	*Candida* sp	CF	20/20	
8	35M	CL,IOFB	8 days	*Staphylococcus epidermidis*	HM	20/100	
9	32M	CL	3 months	*Aspergillus niger*	HM	enucleated	Infection three months after primary repair

TABLE I - continued

Case No.	Age,yr/ Sex	Type of trauma	Time from trauma to treatment	Organism	Initial visual acuity	Visual outcome	Comment
10	24M	Wooden stickCL	2 days	*Streptococcus pneumoniae*	HM	20/50	Postoperatively developed giant retinal tear that was treated with prophylactic laser photo coagulation
11	43M	Self-sealed CL, IOFB	5 days	*Staphylococcus epidermidis*	20/100	20/60	
12	28F	Self-sealed CL	5 days	*Streptococcus faecalis*	HM	CF	Postoperatively developed retinal detachment with severe proliferative vitreo retinopathy that was repaired
13	22M	Self-sealed CL, IOFB	7 days	*Staphylococcus epidermidis*	HM	CF	
14	35M	Wooden stick CL	3 days	*Escherichia coli, Enterobacter* sp	HM	CF	Postoperatively developed retinal detachment that was repaired
15	4F	Wire self-sealed CL	3 days	*Staphylococcus aureus*	HM	20/100	
16	32M	CL, IOFB	2 days	*Clostridium perfringens*	LP	eviscerated	Panophthalmitis and orbital cellulitis with marked proptosis and restricted eye movements
17	1 IM	Needle self-sealed CL	7 days	*Coryne-bacterium* sp	LP	CF	
18	8 M	WireCL	8 davs	*Pseudomonas* sp	LP	20/100	

CL = Corneal laceration; IOFB = Intraocular foreign body; LP = Light perception; NLP = No light perception; CF = Counting fingers; CRAO = Central retinal artery occlusion; CRVO = Central retinal vein occlusion

TABLE II - CULTURE RESULTS

Organism	No. of eyes	
	IOFB	No IOFB
Gram-positive		
Staphylococcus epidermidis	4	—
Clostridium perfringens	3	—
Streptococcus sp	—	2
Corynebacterium sp	1	1
Staphylococcus aureus	—	1
Gram-negative		
Pseudomonas sp	—	2
Mixed Bacteria		
Staphylococcus epidermidis and *Moraxella* sp	1	—
Escherichia coli and *Enterobacter* sp	—	1
Fungi		
Candida sp	—	1
Aspergillus niger	—	1
Total	9	9

IOFB = Intraocular foreign body

TABLE III - MICROBIOLOGY OF POST-TRAUMATIC ENDOPHTHALMITIS

Organism	Current study n = 18 %	Other series of post-traumatic endophthalmitis (1-8) n = 129 %
Gram-positive		
S. epidermidis	4 (22.2)	32 (24.8)
S. aureus	1 (5.5)	8 (6)
Streptococcus sp	2 (11.1)	14 (10.8)
Bacillus sp	—	25 (19)
N. asteroides	—	1 (0.8)
Clostridium sp	3 (16.6)	1 (0.8)
Other anaerobic	—	3 (2.3)
Corynebacterium sp	2 (11.1)	2 (1.5)
Gram-negative	2 (11.1)	11 (8.5)
Fungus	2 (11.1)	12 (9)
Mixed		
including *Bacillus* sp	—	7 (5)
including *Clostridium* sp	—	2 (1.5)
Other mixed	2 (11.1)	10 (7.7)
Other	—	1 (0.8)

6) a corneal ring infiltrate (a sign of infection by a virulent organism).

The recent EVS findings (23) were cosnistent with these recommendations that vitrectomy be undertaken for eyes with the worst clinical appearance at the initial visit. The EVS data show that post-cataract surgery endophthalmitis patients who had initial light perception only and underwent immediate pars plana vitrectomy had a three times greater chance than those who underwent vitreous tap or biopsy of achieving 20/40 final visual acuity (33% vs 11%), almost double the chance of achieving 20/100 final visual acuity (56% vs 30%) and less than half the risk of severe loss of visual acuity to less than 5/200 (20% vs 47%).

Post-traumatic endophthalmitis still carries a poor visual prognosis. The precipitating injury, microbiology, and associated inflammation combine to dictate the final visual outcome. In our series, only 44% of culture-positive cases achieved visual acuity better than 20/400. Recent studies (2, 4-8) of post-traumatic endophthalmitis report final visual acuities of 20/400 or better in only 27% (29/106) of patients. Reasons for the guarded prognosis include the associated ocular injuries that can obscure the symptoms and signs of early endopthalmitis, resulting in delays in diagnosis and appropriate treatment. In addition, concomitant injuries may directly cause ocular damage that limits ultimate visual recovery. Other factors that contribute to the poor visual prognosis in these patients include polymicrobial infections and the virulence of the infecting organisms (1-8, 13). Consequently, the treating ophthalmologist must always keep a high index of suspicion for infection in the setting of trauma. It is our clinical impression that a delay in diagnosis and starting therapy is an adverse factor in the visual result with post-traumatic endophthalmitis. Retinal detachment occurring after the initial treatment is an additional factor affecting the final visual outcome. In this series, four retinal detachments occurred after the initial pars plana vitrectomy, and were successfully managed by retinal reattachment surgery.

The incidence of endophthalmitis after penetrating ocular trauma has been reported to be between 2.4% and 17% (5, 8, 13, 24-26). Penetrating injuries in a rural environment had a higher incidence of post-traumatic endophthalmitis (30%) than injuries in a non-rural setting (11%) (13). In addition, an intraocular foreign body increases the risk of endophthalmitis after penetrating ocular injury (5, 8). Because of the substantial incidence of endophthalmitis after penetrating trauma, careful consideraton should be given to the use of prophylactic antimicrobial therapy. The purpose of prophylaxis is to provide effective antibiotic levels as fast as possible against a broad range of organisms.

The use of systemic antibiotics for the prevention of post-traumatic endophthalmitis is recommended in patients with ruptured globe (4, 5, 7). Ariyasu et al (27) demonstrated microbial contamination of the anterior chamber at the time of repair in one third of the ruptured globes they studied. None of these eyes developed clinical endophthalmitis. The incidence of positive anterior chamber cutlures was significantly lower in patients receiving intravenous antibiotics before wound repair than in patients not given prophylaxis. These data support the prophylactic use of broad-spectrum intravenous antibiotics to avoid post-traumatic endophthalmitis by reducing the incidence of intraocular microbial contamination.

Good coverage for most organisms is obtained with intravenous vancomycin and a third-generation cephalosporin such as ceftazidime which can penetrate the vitreous cavity, reaching effective levels in inflamed aphakic experimental eyes (28, 29). Ceftazidime provides effective coverage for gram-negative intraocular infections (9, 28), and vancomycin provides coverage for gram-positive organisms (9, 29). Aminoglycosides such as gentamicin and amikacin penetrate poorly into the vitreous cavity after intravenous administration even in traumatized eyes (30, 31) and therefore are not as effective. It should be stressed that some of our cases developed endophthalmitis despite prophylactic broad-spectrum intravenous antibiotics. These cases indicate that prophylactic antimicrobial therapy does not completely prevent bacterial infection.

Eyes with retained intraocular foreign bodies are clearly at risk of infectious endophthalmitis because 28% of all eyes with foreign bodies have positive intraocular cultures (32). Prompt evaluation and surgical removal of acute retained intraocular foreign bodies are therefore recommended. Prompt vitrectomy within hours of presentation removes the intraocular foreign body which may be hardboring infectious material, and irrigates the eye with sterile solution, thereby potentially reducing the amount of infectious material within the eye. Thompson et al (26) found that a delay in prima-

ry repair of the ruptured globe of more than 24 hours caused the risk of infectious endophthalmitis fourfold in eyes with retained intraocular foreign bodies.

The use of prophylactic intravitreal antibiotics should be considered in eyes with foreign bodies potentially contaminated with organic matter or soil (32), and in eyes suspected of having infectious endophthalmitis at the time of intraocular foreign body removal (26). Boldt et al (13) in their series of rural endophthalmitis, isolated *Bacillus* species in 46% of cases. Because of this high incidence they strongly recommend the use of prophylactic broad-spectrum intravitreal antibiotics to specifically cover *Bacillus* species in cases of penetrating ocular trauma in a rural setting.

Initial intravitreal antibiotic therapy has usually to be selected before a definitive diagnosis of the infective organisms comes from the laboratory. The antibiotics must provide broad coverage of the most likely organisms. Vancomycin covers gram-positive organisms including *Bacillus* species and methicillin (oxacillin)-resistant *Staphylococcal* isolates. Approximately 35% to 40% of coagulase-negative *Staphylococci* isolated from endophthalmitis cases are resistant to methicillin/oxacillin, and consequently cephalosporin (33-35). Recently, concern has been expressed regarding the choice of aminoglycosides as the companion drug to vancomycin for intravitreal injection in the initial treatment of patients with endophthalmitis. The concern arises because of reports suggesting that gentamicin and amikacin may cause macular infraction (36, 37). Ceftazidime is a third-generation cephalosporin with a broad spectrum of activity and particularly good coverage of gram-negative bacteria. Ceftazidime provides effective coverage for gram-negative intraocular infections (9, 28). In the light of these data, the combined use of intravitreal vancomycin (1.0 mg) and ceftazidime (2.25 mg) is recommended for the treatment and prophylaxis of endophthalmitis.

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Reprint requests to:
Ahmed M. Abu El-Asrar, M.D., Ph.D.
Department of Ophthalmology
King Abdulaziz University Hospital
Airport Road
P.O. Box 245
Riyadh 11411, Saudi Arabia

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