• Clinical Research •

Poor prognostic factors in post-traumatic endophthalmitis following open globe injury

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Abstract

● **AIM:** To demonstrate prognostic factors for poor visual outcome in patients with post-traumatic endophthalmitis (PTE) following open globe injury.

● **METHODS:** A retrospective study was conducted on 66 patients (66 eyes) with PTE following open globe injury from 2005 to 2015. Potential factors accounting for good and poor visual outcome were statistically analyzed by Chi-square test and Logistic regression model.

● **RESULTS:** In 66 cases, 39 cases (59%) had a poor visual outcome. Univariate and multivariate Logistic regression analysis identified retained intraocular foreign body (IOFB) as the only factor significantly associated with poor visual outcome [adjusted odds ratio, 4.62; 95% confidence interval (1.04-20.53); *P*=0.04]. The most common causative agents were gram-positive organisms (83%), of which *Bacillus cereus* (33%), was the most common pathogen. All cases received intravitreal antibiotic injections. Oral ciprofloxacin was the most used systemic antibiotic (33%). Pars plana vitrectomy was performed in 83% (55/66) of cases. At 6mo follow-up, mean BCVA was 1.74±0.72 logMAR units.

● **CONCLUSION:** In patients with PTE following open globe injury, the only predictor of poor visual outcome is the presence of IOFB. *Bacillus cereus* is the most isolated microorganism.

● **KEYWORDS:** post-traumatic endophthalmitis; open globe injury; intraocular foreign body
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INTRODUCTION

Open globe injury is a devastating ocular condition that requires urgent medical attention, given that it may lead to disastrous complications including post-traumatic endophthalmitis (PTE). The reported incidence rate of endophthalmitis following open-globe injury ranges from 3.1% to 11.9% without an intraocular foreign body (IOFB) and 3.8% to 48.1% with an IOFB[1]. Overall, the visual outcome associated with PTE is worse than that with post-operative endophthalmitis[2-4]. Few researchers have previously reported factors that significantly influence visual prognosis in patients with PTE including visual acuity at initial presentation[5-8], length of laceration[8], microbe virulence[5,9], presence of an IOFB[6], presence of retinal detachment[5,10] and timing of treatment[7-8,10].

Our study aims to identify prognostic factors for poor visual outcome in patients with PTE following open globe injury with a reliable statistical method. In addition, this report from South East Asia includes a mini review of prognostic factors for poor visual outcome in PTE.

SUBJECTS AND METHODS

Ethical Approval The study followed the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of Rajavithi Hospital. The need for informed consent was waived due to the retrospective nature by the Ethics Committee of Rajavithi Hospital. Nothing has specifically linked to any patients.

A retrospective chart review was done on all endophthalmitis patients and cases experiencing open-globe injury who were evaluated at the Department of Ophthalmology, Rajavithi Hospital, Bangkok, Thailand from 2005 to 2015. All patients

Table 1 Demographic data and a clinical summary of patients with post-traumatic endophthalmitis

Parameters	Total (*n*=66)	Poor visual outcome (*n*=39)	Good visual outcome (*n*=27)	*P*[a]
Male	59 (89%)	37 (95%)	22 (81%)	0.11[b]
Age at presentation (y)	39±18 (4-76)	38±17 (4-71)	40±19 (6-76)	0.51[c]
Diabetes mellitus	1 (2%)	1 (3%)	0	1.00[b]
Presenting BCVA > counting finger (*n*=64)	10 (16%)	4 (11%)	6 (23%)	0.30[b]
Zone of ocular injury (*n*=60)				
I	48 (80%)	32 (84%)	16 (73%)	0.33[b]
II	12 (20%)	6 (16%)	6 (27%)	0.33[b]
Wound closure within 24h (*n*=33)	22 (67%)	15 (71%)	7 (58%)	0.47[b]
Hypopyon	35 (53%)	19 (49%)	16 (59%)	0.40
Lens capsule rupture (*n*=64)	37 (58%)	23 (62%)	14 (52%)	0.41
Intraocular foreign body	16 (24%)	13 (33%)	3 (11%)	0.03
No view of optic disc from dilated fundus examination (*n*=54)	48 (89%)	29 (91%)	19 (86%)	0.68[b]
Retinal detachment at presentation	16 (24%)	11 (28%)	5 (19%)	0.37
Duration between trauma and intravitreal antibiotic treatment <3d (*n*=56)	35 (63%)	12 (34%)	9 (43%)	0.52
Intravitreal injections of antibiotics	66 (100%)	39 (100%)	27 (100%)	1.00[b]
Vitrectomy	55 (83%)	32 (82%)	23 (85%)	1.00[b]
Vitrectomy within 24h after admission (*n*=55)	14 (25%)	7 (22%)	7 (30%)	0.47

BCVA: Best-corrected visual acuity. [a]Chi-square test; [b]Fisher's exact test; [c]Independent *t*-test.

who were diagnosed with PTE following open globe injury were included in the study. Exclusion criteria were post-operative endophthalmitis, endophthalmitis without recent history of open globe injury, incomplete clinical data, and follow-up time less than 1mo. Patients with PTE following open globe injury diagnosed by clinical and/or microbiological evidence were included in the study. The diagnostic criteria for PTE encompassed all of the following clinical features: 1) history of recent open globe injury within 4wk; 2) marked inflammation of the anterior and posterior segment with or without hypopyon; 3) retinal periphlebitis or retinitis (localized or diffuse)[11].

Collected data included patient demographics, nature of ocular trauma, timing and sequence of traumatic events, ocular findings, microbiological characteristics, treatment modalities, and visual outcomes. The decision to culture intraocular contents was made only in certain cases, based on the medical facility and patient safety concerns. Patients with PTE immediately underwent vitreous tap and/or vitrectomy to isolate organisms which was followed by intravitreal injections of antibiotics. The specimens were inoculated within 15min of collection on blood agar, chocolate agar, Sabouraud dextrose agar, and thioglycolate broth. Systemic antibiotics were employed depending on surgeons' preferences. Both culture-positive and culture-negative cases were included. Indications for pars plana vitrectomy (PPV) included: 1) poor visual acuity at presentation or worsening visual acuity after intravitreal antibiotic injections, based on the surgeon's discretion; 2) presence of IOFB; 3) diagnosis of retinal detachment confirmed by ophthalmoscopy or ultrasonography.

Statistical Analysis Snellen visual acuity of the affected eye was converted to the logarithm of the minimum angle of resolution (logMAR). The following scale was applied to logMAR values: counting fingers, 2.00; hand motion, 2.30; light perception, 2.60; and no light perception, 2.90. Poor visual outcome was defined as best-corrected visual acuity (BCVA) worse than counting fingers at 1-month follow-up. Descriptive analyses and identification of prognostic factors for PTE were performed using the IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY, USA: IBM Corp; 2011). A univariate analysis by Chi-square test or Fisher's exact test was performed to indicate the significance of categorical variables. An independent *t*-test was used to compare continuous variables. Variables that were significant in the univariate analysis were examined in a multiple Logistic regression analysis to predict independent factors affecting poor visual outcome of PTE following open-globe injury. All statistical tests were two-tailed and significance was defined as $P<0.05$.

RESULTS

General Data Of the 1393 cases of open globe injury we treated during the past 11y, 91 patients (0.6 cases per 100 person-years) developed PTE. Of these, 66 eyes of 66 patients with adequate clinical data were included in the study. Table 1 shows demographic data and a clinical summary of patients with PTE. Eighty-nine percent (59/66) were males. Mean age

at presentation was 39±18 (range, 4-76)y. Figure 1 demonstrates PTE patients' distribution of ages following open globe injury. Eighty-five percent (56/66) of cases were covered by the universal coverage health scheme. According to Birmingham Eye Trauma Terminology (BETT), the most common type of open globe injury was rupture (30/66, 46%), followed by penetration (20/66, 30%), and IOFB (16/66, 24%). Most IOFBs (15/16, 94%) were not organic material. The foreign body composition most found was metallic material (14/16, 88%). Ninety-four percent of IOFBs were in the posterior segment. Mean BCVA at the time of endophthalmitis presentation was 2.32±0.34 logMAR units. Eighty-four percent (54/64) had BCVA worse than counting fingers while 34% (22/64) had presenting BCVA worse than hand motion. Most cases (80%) had zone 1 injury and underwent primary wound closure within 24h (67%). A slit-lamp examination revealed hypopyon in 53% (35/66) and lens capsule rupture in 58% (37/64) of patients. Twenty-four percent (16/66) of cases had retinal detachment at initial presentation and 14% (9/66) developed retinal detachment after therapeutic vitrectomy. Through average follow-up of 15±24 (range, 1-132)mo, 6 cases (9.1%) developed phthisis bulbi.

Microbiological Analysis Vitreous sampling was performed in 79% (52/66) yielding positive cultures in 35% (18/52) of samples. The most common causative agents were gram-positive organisms (83%), with the most common pathogen being *Bacillus cereus* (33%), followed by *Enterococcus spp.* (16.7%). Fungus was not identified from any cultures. Table 2 shows a list of isolated organisms from vitreous cultures. The clinical course of 18 PTE patients with positive intraocular cultures is presented in Table 3. Subgroup analysis between culture-positive and culture-negative cases was conducted to compare visual acuity changes between initial presentation and 1-month follow-up. Culture-positive cases were significantly associated with visual acuity improvement at 1-month follow-up (P=0.03).

Visual Outcome and Therapeutic Data The average BCVA during follow-up of patients with PTE at 1mo (2.09±0.42 logMAR units), 3mo (1.98±0.70 logMAR units) and 6mo (1.74±0.72 logMAR units) was better than presenting BCVA. At 1mo, 43% (28/64) had vision improvement while 23% (15/64) had worsening vision. Figure 2 demonstrates the distribution of visual changes and the average BCVA of each group.

All cases received intravitreal antibiotic injections of which vancomycin and ceftazidime were most widely used (65/66, 98%). Systemic antibiotics were administered in 71% (47/66) of patients and oral ciprofloxacin was the most common antibiotic used. Of the 55 cases that required vitrectomy, 16 cases had IOFB and underwent IOFB removal successfully. Of these, thirty-eight cases (69%) underwent PPV with lens extraction including 34 cases being left aphakic and 4 cases with intraocular lens placement. Intraocular tamponades were used in 18 patients and comprised of perfluoropropane gas

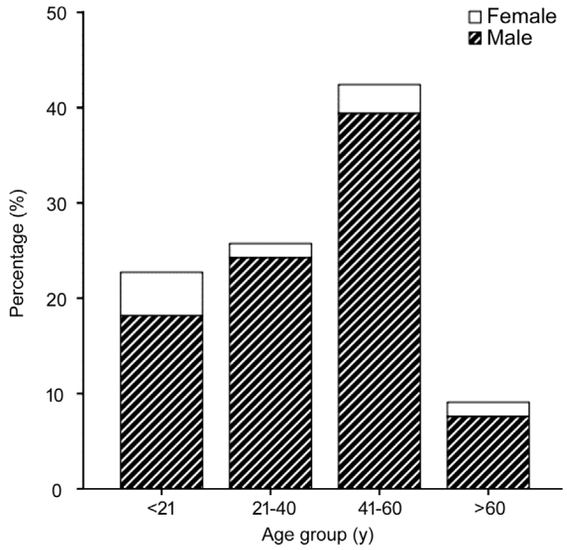

Figure 1 PTE patients' distribution of ages following open globe injury.

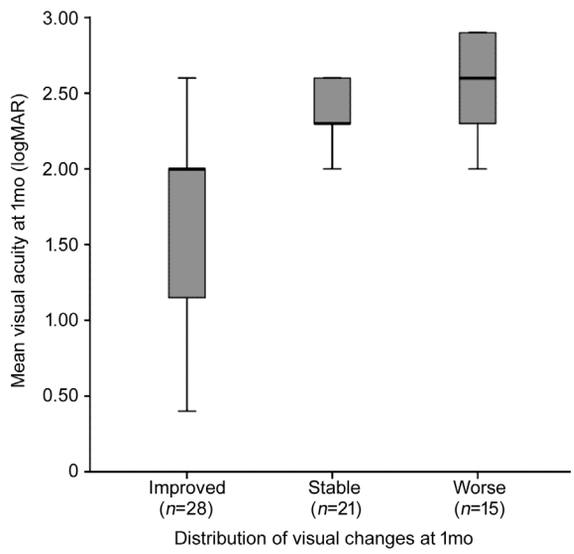

Figure 2 The distribution of visual changes and the average BCVA of each group.

Table 2 List of isolated organisms from vitreous cultures (n=18)

Organisms	Frequency (n)	Rate (%)
Gram-positive	15	83.3
Bacillus cereus	6	33.3
Enterococcus spp.	3	16.7
Staphylococcus aureus	2	11.1
Staphylococcus epidermidis	1	5.5
Staphylococcus haemolyticus	1	5.5
Streptococcus pneumoniae	1	5.5
Streptococcus viridans	1	5.5
Gram-negative	3	16.7
Pseudomonas stutzeri	1	5.5
Enterobacter cloacae	1	5.5
Serratia rubidaea	1	5.5

Table 3 Clinical course of post-traumatic endophthalmitis patients with positive intraocular cultures

Case	Sex/age/eye	Inflicting object/ BETT score	Causative organisms	Antibiotic treatment (local, systemic)	Pars plana vitrectomy	Enucleation	Complications	Initial BCVA	Final BCVA
1	M/18/L	Wood/rupture	*Bacillus cereus*	IVC, vancomycin, ceftazidime	Y	N	-	LP	NLP
2	M/62/L	Wood/rupture	*Bacillus cereus*	IVC, vancomycin, ceftazidime	Y	N	RRD	LP	HM
3	M/49/L	Metal/rupture	*Bacillus cereus*	IVC, Clindamycin	Y	Y	-	LP	NA
4	M/60/R	Plastic/rupture	*Bacillus cereus*	IVC, vancomycin, ceftazidime	Y	N	TRD	LP	HM
5	M/17/R	Metal/IOFB	*Bacillus cereus*	IVC, cefazolin, gentamycin	Y	N	-	HM	NLP
6	F/10/L	Needle/penetrating	*Bacillus cereus*	IVC, cefazolin, gentamycin	Y	N	-	HM	CF
7	M/38/R	Metal/penetrating	*Enterococcus fecalis*	IVC	Y	N	-	HM	20/200
8	F/76/L	Metal/penetrating	*Enterococcus fecalis*	IVC, cefazolin, gentamycin	Y	N	-	LP	20/125
9	M/68/L	Metal/penetrating	*Enterococcus faecium*	IVC	Y	N	OHT	HM	20/200
10	M/45/L	Metal/rupture	*Staphylococcus aureus*	IVC, ciprofloxacin	Y	N	RRD	HM	HM
11	M/8/R	Wood/rupture	*Staphylococcus aureus*	IVC, cefazolin, gentamycin	Y	N	-	CF	20/250
12	M/29/L	Metal/IOFB	*Staphylococcus epidermidis*	IVC, cefazolin, gentamycin	Y	N	-	LP	CF
13	M/51/L	Metal/rupture	*Staphylococcus haemolyticus*	IVC, cefazolin, gentamycin	Y	N	RRD	LP	HM
14[a]	M/68/R	Nail/penetrating	*Streptococcus pneumoniae*	IVC, ciprofloxacin	N	Y	-	NLP	NA
15	M/59/R	Metal/penetrating	*Streptococcus viridans*	IVC, ciprofloxacin	Y	N	-	HM	CF
16	M/18/L	Metal/IOFB	*Pseudomonas stutzeri*	IVC, vancomycin, ceftazidime	Y	N	-	LP	CF
17	M/15/L	Plastic/rupture	*Enterobacter cloacae*	IVC	Y	N	-	LP	LP
18	F/52/L	Metal/rupture	*Serratia rubidaea*	IVC, ciprofloxacin	Y	N	-	HM	CF

BETT: Birmingham Eye Trauma Terminology; BCVA: Best-corrected visual acuity; M: Male; F: Female; R: Right eye; L: Left eye; IVC: Intravitreal injection of vancomycin and ceftazidime; Y: Yes; N: No; LP: Light perception; NLP: No light perception; HM: Hand motion; NA: Not available; CF: Counting fingers; RRD: Rhegmatogenous retinal detachment; TRD: Tractional retinal detachment; OHT: Ocular hypertension. [a]The patient presented with impending panophthalmitis and underwent immediate enucleation on admission.

(11 cases) and silicone oil (7 cases). We compared patients undergoing PPV and those not undergoing PPV in terms of BCVA changes, BCVA at 1, 3, and 6mo follow-up. We did not find a statistically significant difference between the 2 different management strategies. Ocular complications were present in 53% (35/66) of cases (Table 4). A second PPV was performed in eyes with rhegmatogenous retinal detachment except for one eye, which developed phthisis bulbi at the final follow-up of 3mo. All eyes developing ocular hypertension were effectively controlled with anti-glaucoma eye drops. One case (1.5%) underwent evisceration and two cases (3%) underwent enucleation.

Univariate and Multivariate Analysis for Visual Prognostic Factors Of all 66 cases, 39 (59%) patients had a poor visual outcome. Univariate and multivariate logistic regression analysis determined retained IOFB as the only factor significantly associated with the poor visual outcome group [adjusted odds ratio, 4.62; 95% confidence interval (1.04-20.53); P=0.04; Table 5]. There was no significant correlation between visual prognosis and demographic data, type and zone of laceration, presenting BCVA, timing of treatment, virulence of the microbe and presence of retinal detachment.

Table 4 Postoperative complications in patients with post-traumatic endophthalmitis following open globe injury (n=66)

Complication	Number (%)
Rhegmatogenous retinal detachment	25 (38)
Ocular hypertension	7 (11)
Retinal break	2 (3)
Macular hole	1 (1)
None	31 (47)

DISCUSSION

Diagnosis of endophthalmitis after open globe injury is complex, given that both severe traumatic conditions and endophthalmitis are associated with intraocular inflammation. Thus, one feature likely to differentiate the two entities is positive isolation of a pathogen. Several previous studies included only culture-proven PTE[2,9,12-15]. However, Rubsamen *et al*[16] demonstrated that 21% of eyes with positive bacterial or fungal cultures showed no evidence of clinically apparent infections, while 22% of clinically diagnosed PTE cases had negative cultures, corresponding with previous studies[17-19]. A negative culture can be due to improper specimen acquisition and isolation technique, which can vary among different settings. Although trauma is a leading cause of endophthalmitis, the presence of clinical infection, despite positive cultures obtained at the time of wound repair, is uncommon[1]. As a result, worsening clinical signs of infection is used for diagnosis of endophthalmitis in most case series of PTE as follows: hypopyon, pupillary fibrin membrane, dense vitritis, necrotizing retinitis or retinal vasculitis[5-7,10,12,20-22]. Worsening inflammatory status in a post-traumatic eye can also derive from lens breach or lens-induced ocular inflammation which can confound the disease process. Also, it was shown to be associated with infection by Sabaci *et al*[9] but not by Jonas *et al*[23]. Therefore, diagnosis of PTE is challenging especially

Table 5 Multiple Logistic regression analysis of poor prognostic factors in post-traumatic endophthalmitis following open globe injury

Factor	*B*	S.E.	95% confidence interval OR (lower-upper)	*P*
Sex (male *vs* female)	2.303	1.200	10.006 (0.952-105.150)	0.055
Presenting BCVA (>counting finger *vs* <counting finger)	1.205	0.786	3.335 (0.714-15.579)	0.126
Presence of intraocular foreign body	1.531	0.761	4.623 (1.041-20.531)	0.044

BCVA: Best-corrected visual acuity.

in traumatic open globe injury. Our work encompassed both culture-positive and culture-negative PTE following open globe injury cases with an incidence rate of 6.5%. Cases of PTE can be classified as culture-independent or culture-positive. The overall incidence of clinically evident or culture-independent PTE ranges from 1.6% to 12.9%[1] which is consistent with our data.

Microorganisms Regarding culture-positive endophthalmitis cases, gram positive organisms were predominant in 83% of cases. This is consistent with previous studies of PTE with gram positive pathogens ranging from 75%-100%[5,9-10,20-22]. The virulence of organisms was a predictive factor for visual outcome following PTE[9]. Highly virulent bacteria (*Streptococcus*, *Bacillus* and gram-negative bacilli)[5,12,20] were present in our series at a rate of 61% though they were not significantly associated with poor visual outcome. *Bacillus cereus* was the most commonly isolated microorganism in our cohort in accordance with previous studies[12,22]. Endophthalmitis caused by *Bacillus* species often results in poor visual outcomes[1,9-11,22,24] and may progress to panophthalmitis or even lead to enucleation or evisceration[1,22]. Our study consistently supported this idea revealing the best final visual outcome of *Bacillus cereus* endophthalmitis was counting fingers. On the other hand, the best final visual outcome in low virulent gram-positive bacterial endophthalmitis (*Staphylococcus spp.* and *Enterococcus spp.*) was 20/125 (Table 3). The visual outcome in *Bacillus cereus* endophthalmitis is worse, even though the average time to receive intravitreal injection of antibiotics in cases infected with *Bacillus cereus* endophthalmitis was 2.5d compared with 6.5d in the low virulence group. Among 6 cases with *Bacillus cereus* endophthalmitis, one case underwent enucleation and two cases developed phthisis bulbi following vitrectomy. Given the low yield of cultures, genomic analysis with panbacterial polymerase chain reaction (PCR) was reported by Cornut *et al*[5] to improve yield of bacterial identification. DNA typing should also have an important role in early detection of fungal pathogens as reported by Ferrer *et al*[25]. Besides, we believe that patients with phacoantigenic reaction mimicking endophthalmitis might also be included in our series as aforementioned.

Prophylaxis and Treatment Antibiotic prophylaxis by intravitreal injection is beneficial for prevention of PTE following open globe injury as shown in animal models[26-27] and clinical trials[28-30]. Though administration of prophylactic intravitreal injections of vancomycin and ceftazidime reduced the risk of endophthalmitis after repair of open globe injuries[29-30], it is not universally accepted[21]. However, we believe there should be specific criteria for prophylactic intravitreal antibiotics to prevent PTE in high-risk cases. Therefore, we propose that high-risk patients meeting one or more of the following risk factors should receive prophylactic intravitreal antibiotics: 1) dirty wound; 2) delay in primary repair of >24h; 3) breach of lens capsule; 4) retained IOFB. The criteria are meant to not only prevent PTE but also, even in failure cases, to provide patients developing PTE with a greater chance to achieve better visual outcome, since mixed and virulent microorganisms could be present in any wound. However, the prophylactic evaluation of intravitreal antibiotics in PTE could not be assessed in this trial. Therefore, the efficacy of intravitreal prophylactic antibiotics needs to be justified by much larger randomized prospective trials.

It is unanimously agreed that prompt treatment is important for all cases of PTE[1]. Treatment modalities for patients developing PTE include empiric antibiotic treatment (intravitreal, systemic) and PPV. In our study, data revealed: 71% received systemic antibiotics, 100% received intravitreal antibiotics and 83% underwent vitrectomy. The low rate of systemic antibiotics administration in our series may be a risk for developing endophthalmitis as described by Schmidseder *et al*[31]. Intravitreal antibiotics were used in all PTE cases and 98% were a combination of vancomycin and ceftazidime. Vancomycin and ceftazidime are safe and effective for intravitreal use at therapeutic concentrations[1,29,32]. Vancomycin is the drug of choice for gram-positive organisms including *Staphylococcus* and *Streptococcus* species. Ceftazidime has an excellent safety profile, a good clinical effect and a possible synergistic effect with vancomycin[1]. However, caution should be exercised when intravitreal antibiotic injection is indicated in open globe injury with clinically suspected endophthalmitis due to: 1) risk of increasing ocular morbidity (wound leakage and suspicion of suprachoroidal hemorrhage or retinal detachment); 2) complications associated with intravitreal injection (vitreous hemorrhage, retinal tear, retinal detachment); 3) development of vancomycin and ceftazidime resistance[29,33-34]. These

warrant the careful use of intravitreal antibiotic injections. We did not encounter wound leakage due to intravitreal injections. All eyes suspicious of retinal detachment initially received systemic antibiotics, while intravitreal injection was omitted, before undergoing PPV with intravitreal antibiotic injection.

Role of vitrectomy for PTE has been proven in most clinical studies. Conservative core vitrectomy, without attempt to remove the posterior hyaloid, was recommended due to risk of creating a retinal break[1,10]. In PTE cases, vitrectomy was performed in 64%-100% which is consistent with our data[5-6,9-10]. However, vitrectomy would undoubtedly pose a higher risk of retinal detachment in an eye with infectious endophthalmitis[35]. It also burdens patients with additional surgical risk, medical expense, and mental pressure[21]. Retinal detachment occurring concomitant with endophthalmitis in our case series was 24%. Fourteen percent (9/66) developed retinal detachment after the first vitrectomy, which the exact cause is still unknown, though we strictly followed the vitrectomy guideline.

Visual Prognosis of Post-Traumatic Endophthalmitis

Comparisons between previous PTE research studies is limited owing to differences in criteria of data collection, overall management, and timing of treatments. In addition, the definition of poor visual outcome to be used as a dependent variable in analysis differed among studies[5-6,9-10]. Furthermore, statistical accuracy and precision are so important when looking for prognostic factors of a certain entity. From a literature review of recent studies, there have been only two case series from Das *et al*[6], and the current study that used multivariate analysis and visual outcome at certain time frames of follow-up instead of final visual outcome.

The influence of endophthalmitis on visual prognosis in an open globe injury was described in the ocular trauma score (OTS). By calculating indicated variables, the given raw score corresponds to a probability percentage for the visual outcome the patient will obtain 6mo after injury[36]. In a recent literature review, 4 major risk factors affecting visual prognosis were described: retinal detachment, virulence of microorganisms, characteristics of ocular wound site and IOFB[1]. Our work presented IOFB as the only independent risk factor for poor visual outcome in PTE following open globe injury which is consistent with previous studies[1,6]. IOFBs can harm visual prognosis in 2 ways: 1) physical and chemical damage; 2) as a vector for delivering pathogens. Cases of retained IOFB with or without PTE also had a higher rate of proliferative vitreoretinopathy (PVR), and vice versa. Factors regarding IOFB demolition effect included type, location and timing of IOFB removal[1]. Risk of developing endophthalmitis may increase in the presence of organic IOFBs[23]. Of 16 cases of IOFBs, 14 (88%) cases had metallic IOFBs, one case had ceramic IOFB and only one case had organic IOFB. All IOFBs residing in the posterior segment of the eye (94%) were associated with a worse visual prognosis than ones located in the anterior segment as described in previous studies[37-39]. Regarding timing of IOFB removal, studied by Jonas and associates, removing retained IOFBs within the first 24h after the injury reduced the risk of PTE and PVR[40]. This guideline should ideally be followed to prevent deleterious sequelae. Unfortunately, only 2 cases of IOFB in our cohort underwent IOFB removal within 24h.

The current study is limited by its retrospective nature, short follow-up, and the fact that some clinical data (relative afferent pupillary defect, optic nerve damage, macular injury) was missing. Though our attempt was to compare prognostic factors among previous studies with a similar purpose, results from these studies are difficult to compare because of their retrospective nature, marked discrepancy of clinical data, and assessment including definition of poor visual outcome for analysis.

In conclusion, the present study identified IOFB as only prognostic factor of poor visual outcome in a large cohort of PTE patients. Though this is not a potentially modifiable factor, we believe that early surgical intervention to remove IOFB in eyes with PTE, which is not statistically significant in our series, is mandatory to achieve better visual outcome as stated by Chaudhry *et al*[7]. Each factor investigated in this study should be performed in further prospective evaluations which may draw more significant conclusions that are more accurate.

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REFERENCES

1 Bhagat N, Nagori S, Zarbin M. Post-traumatic infectious endophthalmitis. *Surv Ophthalmol* 2011;56(3):214-251.

2 Bohigian GM, Olk RJ. Factors associated with a poor visual result in endophthalmitis. *Am J Ophthalmol* 1986;101(3):332-341.

3 Nobe JR, Gomez DS, Liggett P, Smith RE, Robin JB. Post-traumatic and postoperative endophthalmitis: a comparison of visual outcomes. *Br J Ophthalmol* 1987;71(8):614-617.

4 Gokce G, Sobaci G, Ozgonul C. Post-traumatic endophthalmitis: a mini-review. *Semin Ophthalmol* 2015;30(5-6):470-474.

5 Cornut PL, Youssef el B, Bron A, Thuret G, Gain P, Burillon C, Romanet JP, Vandenesch F, Maurin M, Creuzot-Garcher C, Chiquet C, French Institutional Endophthalmitis Study (FRIENDS) Group. A

multicentre prospective study of post-traumatic endophthalmitis. *Acta Ophthalmol* 2013;91(5):475-482.

6 Das T, Kunimoto DY, Sharma S, Jalali S, Majji AB, Nagaraja Rao T, Gopinathan U, Athmanathan S, Endophthalmitis Research Group. Relationship between clinical presentation and visual outcome in postoperative and posttraumatic endophthalmitis in south central India. *Indian J Ophthalmol* 2005;53(1):5-16.

7 Chaudhry IA, Shamsi FA, Al-Harthi E, Al-Theeb A, Elzaridi E, Riley FC. Incidence and visual outcome of endophthalmitis associated with intraocular foreign bodies. *Graefes Arch Clin Exp Ophthalmol* 2008;246(2):181-186.

8 Jiang T, Jiang J, Wang RP, Lei JL, Zhou Y. Visual outcomes and prognostic factors after pars Plana vitrectomy for traumatic endophthalmitis. *Biomed Res Int* 2017;2017:5851318.

9 Sabaci G, Bayer A, Mutlu FM, Karagül S, Yildirim E. Endophthalmitis after deadly-weapon-related open-globe injuries: risk factors, value of prophylactic antibiotics, and visual outcomes. *Am J Ophthalmol* 2002;133(1):62-69.

10 Nicoară SD, Irimescu I, Călinici T, Cristian C. Outcome and prognostic factors for traumatic endophthalmitis over a 5-year period. *J Ophthalmol* 2014;2014:747015.

11 Lieb DF, Scott IU, Flynn HW Jr, Miller D, Feuer WJ. Open globe injuries with positive intraocular cultures: factors influencing final visual acuity outcomes. *Ophthalmology* 2003;110(8):1560-1566.

12 Gupta A, Srinivasan R, Gulnar D, Sankar K, Mahalakshmi T. Risk factors for post-traumatic endophthalmitis in patients with positive intraocular cultures. *Eur J Ophthalmol* 2007;17(4):642-647.

13 Brinton GS, Topping TM, Hyndiuk RA, Aaberg TM, Reeser FH, Abrams GW. Posttraumatic endophthalmitis. *Arch Ophthalmol* 1984;102(4):547-550.

14 Boldt HC, Pulido JS, Blodi CF, Folk JC, Weingeist TA. Rural endophthalmitis. *Ophthalmology* 1989;96(12):1722-1726.

15 Thompson WS, Rubsamen PE, Flynn HW Jr, Schiffman J, Cousins SW. Endophthalmitis after penetrating trauma. Risk factors and visual acuity outcomes. *Ophthalmology* 1995;102(11):1696-1701.

16 Rubsamen PE, Cousins SW, Martinez JA. Impact of cultures on management decisions following surgical repair of penetrating ocular trauma. *Ophthalmic Surg Lasers* 1997;28(1):43-49.

17 Mieler WF, Ellis MK, Williams DF, Han DP. Retained intraocular foreign bodies and endophthalmitis. *Ophthalmology* 1990;97(11):1532-1538.

18 Behrens-Baumann W, Praetorius G. Intraocular foreign bodies. *Ophthalmologica* 1989;198(2):84-88.

19 Ariyasu RG, Kumar S, LaBree LD, Wagner DG, Smith RE. Microorganisms cultured from the anterior chamber of ruptured globes at the time of repair. *Am J Ophthalmol* 1995;119(2):181-188.

20 Asencio MA, Huertas M, Carranza R, Tenias JM, Celis J, Gonzalez-del Valle F. A case-control study of post-traumatic endophthalmitis at a Spanish hospital. *Int Ophthalmol* 2016;36(2):185-194.

21 Zhang Y, Zhang MN, Jiang CH, Yao Y, Zhang K. Endophthalmitis following open globe injury. *Br J Ophthalmol* 2010;94(1):111-114.

22 Essex R, Yi Q, Charles P, Allen P. Post-traumatic endophthalmitis. *Ophthalmology* 2004;111(11):2015-2022.

23 Jonas JB, Knorr HLJ, Budde WM. Prognostic factors in ocular injuries caused by intraocular or retrobulbar foreign bodies. *Ophthalmology* 2000;107(5):823-828.

24 Miller JJ, Scott IU, Flynn HW Jr, Smiddy WE, Murray TG, Berrocal A, Miller D. Endophthalmitis caused by Bacillus species. *Am J Ophthalmol* 2008;145(5):883-888.

25 Ferrer C, Montero J, Alió JL, Abad JL, Ruiz-Moreno JM, Colom F. Rapid molecular diagnosis of posttraumatic keratitis and endophthalmitis caused by Alternaria infectoria. *J Clin Microbiol* 2003;41(7):3358-3360.

26 Alfaro DV, Davis J, Kim S, Bia F, Bogard JF, Briggs JW, Liggett PE. Experimental Bacillus cereus post-traumatic endophthalmitis and treatment with ciprofloxacin. *Br J Ophthalmol* 1996;80(8):755-758.

27 Alfaro DV 3rd, Hudson SJ, Kasowski EJ, Barton CP, Brucker AJ, Lopez JD, Beverly DT, King LP. Experimental pseudomonal posttraumatic endophthalmitis in a swine model. Treatment with ceftazidime, amikacin, and imipenem. *Retina* 1997;17(2):139-145.

28 Soheilian M, Rafati N, Mohebbi MR, Yazdani S, Habibabadi HF, Feghhi M, Shahriary HA, Eslamipour J, Piri N, Peyman GA, Traumatic Endophthalmitis Trial Research Group. Prophylaxis of acute posttraumatic bacterial endophthalmitis: a multicenter, randomized clinical trial of intraocular antibiotic injection, report 2. *Arch Ophthalmol* 2007;125(4):460-465.

29 Abouammoh MA, Al-Mousa A, Gogandi M, Al-Mezaine H, Osman E, Alsharidah AM, Al-Kharashi A, Abu El-Asrar AM. Prophylactic intravitreal antibiotics reduce the risk of post-traumatic endophthalmitis after repair of open globe injuries. *Acta Ophthalmol* 2018;96(3):e361-e365.

30 Narang S, Gupta V, Gupta A, Dogra MR, Pandav SS, Das S. Role of prophylactic intravitreal antibiotics in open globe injuries. *Indian J Ophthalmol* 2003;51(1):39-44.

31 Schmidseder E, Miño de Kaspar H, Kampik A, Klauß V. Post-traumatic endophthalmitis after penetrating eye injury. Risk factors, microbiological diagnosis and functional outcome. *Ophthalmologe* 1998;95(3):153-157.

32 López-Cabezas C, Muner DS, Massa MR, Mensa Pueyo JM. Antibiotics in endophthalmitis: microbiological and pharmacokinetic considerations. *Curr Clin Pharmacol* 2010;5(1):47-54.

33 Sadaka A, Durand ML, Gilmore MS. Bacterial endophthalmitis in the age of outpatient intravitreal therapies and cataract surgeries: host-microbe interactions in intraocular infection. *Prog Retin Eye Res* 2012;31(4):316-331.

34 Pfaller MA, Sader HS, Fritsche TR, Jones RN. Antimicrobial activity of cefepime tested against ceftazidime-resistant Gram-negative clinical strains from North American Hospitals: report from the SENTRY Antimicrobial Surveillance Program (1998-2004). *Diagn Microbiol Infect Dis* 2006;56(1):63-68.

35 Nelsen PT, Marcus DA, Bovino JA. Retinal detachment following endophthalmitis. *Ophthalmology* 1985;92(8):1112-1117.

36 Pieramici DJ, Au Eong KG, Sternberg P Jr, Marsh MJ. The prognostic significance of a system for classifying mechanical injuries of the eye (globe) in open-globe injuries. *J Trauma* 2003;54(4):750-754.

37 De Juan E Jr, Sternberg P Jr, Michels RG. Penetrating ocular injuries. Types of injuries and visual results. *Ophthalmology* 1983;90(11): 1318-1322.

38 Williams DF, Mieler WF, Abrams GW, Lewis H. Results and prognostic factors in penetrating ocular injuries with retained intraocular foreign bodies. *Ophthalmology* 1988;95(7):911-916.

39 Woodcock MG, Scott RA, Huntbach J, Kirkby GR. Mass and shape as factors in intraocular foreign body injuries. *Ophthalmology* 2006;113(12):2262-2269.

40 Jonas JB, Budde WM. Early versus late removal of retained intraocular foreign bodies. *Retina* 1999;19(3):193-197.