



Prognostic factors for open-globe injuries: variables for poor visual outcome

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Abstract

Purpose To determine prognostic factors for open-globe Injuries (OGI).

Methods Open-globe injuries referred to a tertiary referral clinic in Turkey between January 1998 and January 2016 were retrospectively analyzed. Univariate and multivariate logistic regression analyses were conducted to find out the most important variables for poor visual outcome.

Results Six hundred and thirty-three patients were studied with an average age of 24.37 ± 11.1 years (range 1–80). The male/female ratio was 18.6/1. Most of the cases (48.2%) were conflict related, whereas the rate of work, accidental, and sports related cases were (33.1%), (17.9%) and (0.01%), respectively. Final visual acuity (VA) ranged from no perception of light (23%) to 200/200 (17.1%). The number of cases with a final VA $> 20/200$ were 388 (49.3%). Initial visual acuity $< 20/200$, ocular trauma score category 1, zone 3 injury, additional vitrectomy surgery, and lens damage were found to be the main variables related with poor visual outcome in multivariate logistic regression analysis.

Conclusion Besides ocular trauma score category and initial VA; zone of injury, additional surgeries, and initial lens damage had negative effects on visual outcome in OGI.

Introduction

Ocular trauma may have a significant impact on the patient's quality of life. Open-globe injury (OGI), full-thickness laceration of the eye wall, can cause a significant visual loss [1]. OGI has a global incidence rate of 3.5 per 100,000 persons per year, which corresponds to 203,000 OGI per year worldwide [2]. Kuhn et al. [3] reported prognostic factors for predicting final visual outcome by describing ocular trauma score (OTS) long before. However, recent progress in the management of ocular trauma may modify these factors. We studied different variables to predict final visual outcome in OGI.

Patients and methods

We retrospectively collected data pertaining to 1080 patients who were referred to our clinic (Gulhane School of Medicine, Department of Ophthalmology, Ankara, Turkey) between January 1998 and January 2016. We included the OGI cases, which were satisfying Birmingham Eye Trauma Terminology system (BETTS). We excluded the cases with missing data and sequel cases (already lost the chance of further treatment at presentation (e.g. phthisis bulbi) at the time of admission. We have included and analyzed 787 eyes of 633 patients in our study. We recorded demographics, age, initial, and final ocular findings, OTS, time of injury, time interval to first surgery, duration of hospitalization, type of injury, cause of injury, zone of injury, and type and number of surgeries performed. We tried to find out the most relevant variables to predict final outcome in OGI. The final VA was accepted as the VA at last visit according to patient's records.

We studied male gender, primary and additional pars plana vitrectomy (PPV) surgery, terror-relation, initial VA $\geq 20/200$, > 1 month of hospitalization, corneal laceration, iris prolapse, lens damage, hyphema, vitreous hemorrhage, vitreous prolapse, retinal detachment, initial PVR,

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endophthalmitis, relative afferent pupillary defect (RAPD), intravitreal foreign body, retinal foreign body, zone 3 injury, OTS category 1 variables in univariate logistic regression analysis.

We accepted the final VA $\geq 20/200$ as success criteria. We also divided patients into three age groups, four time interval to first surgery groups, two number of surgery groups and compared according to success criteria. We defined first surgery as the initial intervention that performed without classifying them primary wound closure or primary wound closure with vitrectomy surgery.

We used χ^2 analysis for categorical variables. We used binary logistic regression (uni/multivariate) analysis to discover prognostic values of OGI. We presented average \pm standard deviation and % and frequency values for descriptive statistics. We ran SPSS for Windows 20.0 for statistical analysis and accepted $p \leq 0.05$ as significant.

Results

The average age and follow-up time of patients were 24.37 ± 11.1 (1–80 year) and 8.2 ± 15.2 (1–180 month), respectively. The male/female ratio was 18.6/1. Bilateral OGI was present in 24.3% of the eyes. Three hundred seventy nine of our cases (48.2%) were terror-related OGI; whereas the rate of work, accidental, and sports related cases were 261 (33.1%), 141(17.9%), 6 (0.01%), respectively. We found the leading injury time interval was between 3 and 6 pm (22.1%). We detected none of the cases had protective eye wear at the time of injury.

Most of our cases (62.1%) underwent first surgery within 6 h of injury. We did not find any statistically significant differences among four time interval groups according to final VA success criteria ($p = 0.755$) (Table 1).

The most frequent types of injury were intraocular foreign body (IOFB) (42.1%) and penetrating injury (36.5%) (Table 1). We compared four types of injury according to final VA success criteria, and found statistically significant differences ($p < 0.001$) (Table 1). We identified the source of the difference as penetrating injury group and IOFB-rupture groups with further paired comparisons.

The leading causes of injury were land mines (26.6%) and hand grenades (13.9%) (Table 2). We analyzed the effect of the object of injury on final VA. We found land mine and broken glass injury have a detrimental effect on final VA ($p < 0.001$) (Table 2).

Our cases were mostly in 19–50 year age group (89.5%). We compared 3 age groups according to final VA success criteria. We detected three groups were significantly different statistically ($p = 0.005$). We identified the source of the difference was from relatively higher final VA of 0–18 age group than other two age groups ($p = 0.006$, $p = 0.048$).

Table 1 Time interval to primary surgery and injury types with FVA comparisons between groups

Time interval to primary surgery and FVA comparisons between groups							
			FVA < 20/200		FVA > 20/200		p^a
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
0–1 h	143	22.6	87	22	95	24.2	0.755
1–6 h	393	62.1	243	61.5	241	61.5	
6–24 h	59	9.3	43	10.9	35	8.9	
> 24 h	38	6.0	22	5.6	21	5.1	

Injury types and FVA comparisons between groups							
Injury type			FVA > 20/200		FVA < 20/200		p^a
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
IOFB	331	42.1	165	49.9	166	50.1	< 0.001
Penetrating	288	36.5	101	35.1	187	64.9	
Globe rupture	134	17.1	106	79.2	28	20.8	
Perforating	34	4.3	23	67.7	11	32.3	

n number of cases, *FVA* final visual acuity, *IOFB* intraocular foreign body

^achi-square test

The leading zone of injury was combined zone injuries (zone 1 + 2 + 3) (51.2%) (Table 2). The rate of zone 3 was 64.5%. The highest final VA success rate was in zone 1 injury (98.1%), whereas the lowest final VA success rate was in zone 2 + 3 (26.7%) (Table 2).

The average OTS was 2.1. The majority of cases were in OTS category 1 (36.4%) and 2 (32.9%) (Table 3). The most frequent initial ocular findings were corneal laceration (53.2%), corneal edema (51.2%), shallow anterior chamber (50.9%), vitreous hemorrhage (58.1%), retinal hemorrhage (49.5%), and vitreous prolapse (48.9%).

The rates of initial and final VA $\geq 20/200$ was 24.01% and 48.3%, respectively (Table 3) ($p < 0.000$). The average number of surgeries in each eye was 1.93 with a total of 1524 surgeries. We detected a statistically significant difference in final VA success criteria between the < 2 surgery group (58%) and > 2 surgery group (37.4%) ($p < 0.001$).

PPV (34.8%) and silicone oil injection (18.9%) were performed as an additional intervention in most of the cases. The rate of PPV surgery (primary or additional) was 53.3%. In cases underwent PPV surgery, the rate of cases with VA $\geq 20/200$ were 17.6% prior to PPV, and raised to 37.1% after PPV, which was statistically significant ($p < 0.001$).

The rates of endophthalmitis and evisceration/enucleation in our study were 2% and 11.9%, respectively. The most frequent vision threatening complications in our study were retinal detachment (27.9%), PVR (24.9%), and aphakia (22.7%).

Table 2 Zone and causes of injuries with FVA comparisons between groups

Zone of injury and FVA comparisons between groups							
Zone of injury	<i>n</i>	%	FVA >20/200 < 20/200				<i>p</i> ^a
			<i>n</i>	%	<i>n</i>	%	
Zone 1 + 2 + 3	403	51.2	121	30	282	70	<i>p</i> < 0.001
Zone 1 + 2	211	26.8	165	78.2	46	21.8	
Zone 1	54	6.9	53	98.1	1	1.9	
Zone 3	50	6.4	21	42	29	58	
Zone 2 + 3	45	5.7	12	26.7	33	73.3	
Zone 2	24	3	20	83.3	4	16.7	
Causes of injuries and FVA comparisons between groups							
Cause of injury	<i>n</i>	%	FVA >20/200 < 20/200				<i>p</i> ^a ; RR
			<i>n</i>	%	<i>n</i>	%	
Land mines	209	26.6	82	39.2	127	60.8	<i>p</i> < 0.001, 1.311
Hand grenades	109	13.9	41	37.6	68	62.4	<i>P</i> = 0.006, 1.293
Missile	46	5.8	28	60.9	18	39.1	<i>p</i> = 0.122, 1.239
Broken glass	42	5.3	32	76.2	10	23.8	<i>p</i> < 0.001, 0.462
Shrapnel	37	4.7	17	45.9	20	54.1	<i>p</i> = 0.630, 0.919
Rocket	33	4.2	15	45.5	18	54.5	<i>p</i> = 0.609, 0.909

n number of cases, *FVA* final visual acuity, *RR* relative risk (with 95% confidence interval)

^achi-square test

Male gender, additional PPV surgery, terror-relation, initial VA < 20/200, > 1 month hospitalization, corneal laceration, hyphema, vitreous prolapse, retinal detachment, initial PVR, RAPD, intravitreal foreign body, zone 3 injury, and OTS category 1 were statistically significant variables in univariate analysis (Table 4). However, initial VA < 20/200, OTS category 1, zone 3 injury, additional PPV surgery and lens damage were the main variables in multivariate logistic regression analysis (Table 5).

Discussion

The first standard procedure in OGI is to restore structural integrity as soon as possible. Primary enucleation is reserved for severely injured eyes with a poor visual potential.

Similar to previous studies [4, 5], OGI affected predominantly males in the current study. It is noteworthy that the rate of bilateral involvement in our study was 24.3%, which was rather higher than previously reported large

Table 3 Initial and final visual acuities and OTS categories of our cases

Initial and final visual acuities				
	IVA		FVA	
	<i>n</i>	%	<i>n</i>	%
NLP	147	18.7	181	23
LP	220	28	108	13.7
LP-HM	102	13	41	5.2
1/200–19/200	129	16.4	69	8.8
20/200–20/50	75	9.5	144	18.3
≥ 20/40	114	14.5	244	31
Total	787	100	787	100
OTS categories of our cases				
OTS raw points	OTS Category	<i>n</i>	%	
0–44	1	287	36.4	
45–65	2	259	32.9	
66–80	3	134	17.1	
81–91	4	87	11.1	
92–100	5	20	2.5	

n number of cases, *IVA* initial visual acuity, *FVA*, final visual acuity, *NLP* no light perception, *LP* light perception, *HM* hand movements

series reported a rate between 7.54 and 22% [6, 7]. Recent studies reported this might be due to a high percentage (48.2%) of terror-related injuries in the current study.

Kanoff et al. [8] reported that the occurrence of injury was frequently at 10:00–11:00 and 15:00–16:00 in work-related OGI. We similarly confirmed this as injury occurred mostly between 3 and 6 pm (22.1%). Thach et al. [7] reported 9.2% of 797 cases had protective eye wear. None of the cases had protective eye wear at the time of injury in this study. This could be owing to the upsetting fact that there is no regulatory rule for wearing protective eye wear for security forces in our country.

In a study of Pieramici [9], though 89% of cases underwent primary repair within 24 h of the injury, no significant effect of time interval to first surgery on visual outcome was shown. Similarly, we did not find any significant difference among four time interval groups according to final VA success criteria in our study (*p* = 0.755) (Table 1). Sobaci et al. [6] compared two groups: surgery within 24 h of injury and > 24 h for favorable visual outcome, and did not find statistically significant difference between two groups.

The type of injury was predictive of visual outcome in our study. Consistent with previous studies [6], penetrating injury had a higher success rate, not statistically different from IOFB cases in the current study. Globe rupture and perforating injuries had the lowest success rate, and they were not statistically different (Table 1). Ahmediah et al. [10] reported toxic IOFB had a poor visual prognosis.

Table 4 Prognostic variables on FVA in univariate analysis

		< 20/200		≥ 20/200		<i>B</i>	<i>p</i>	OR	CI	
		<i>n</i>	%	<i>n</i>	%					
Male gender	Present	387	98	367	93.6	1.192	0.004	3.295	1.468	7.399
	Absent	8	2	25	6.4					
Primary PPV surgery	Present	40	10.1	45	11.5	–	0.541	0.869	0.544	1.364
	Absent	355	89.9	347	88.5	0.141				
Additional PPV surgery	Present	122	33.5	242	66.5	1.253	0.000	3.500	2.608	4.699
	Absent	153	36.1	270	63.9					
Terror-related	Yes	229	60.4	150	39.6	0.8	0.000	2.226	1.673	2.960
	No	166	40.7	242	59.3					
IVA > 20/200	Present	380	63.1	222	36.9	2.965	0.000	19.399	11.156	33.734
	Absent	15	8.1	170	91.9					
> 1 month hospitalization	Present	49	77.7	14	22.3	1.341	0.000	3.824	2.074	7.049
	Absent	346	47.7	378	52.3					
Corneal laceration	Present	216	45.8	256	54.2	0.423	0.004	1.527	1.146	2.034
	Absent	178	56.5	137	43.5					
Iris prolapse	Present	169	50.1	163	49.9	0.060	0.679	1.062	0.8	1.409
	Absent	225	49.4	230	50.5					
Lens damage	Present	116	48.3	124	51.7	–	0.540	0.909	0.671	1.232
	Absent	278	50.8	269	49.2	0.095				
Hyphema	Present	224	54.6	186	45.4	0.393	0.006	1.481	1.118	1.962
	Absent	170	45.1	207	54.9					
Vitreous hemorrhage	Present	323	51.5	304	48.5	0.293	0.1	1.340	0.946	1.900
	Absent	71	44.3	89	55.7					
Vitreous prolapse	Present	197	57.8	144	42.2	0.549	0.000	1.731	1.302	2.301
	Absent	197	44.2	249	55.8					
Retinal detachment	Present	191	77.6	55	22.4	2.264	0.000	9.621	6.240	14.835
	Absent	203	37.5	338	62.5					
Initial PVR	Present	19	76	6	24	1.179	0.013	3.251	1.284	8.229
	Absent	375	49.2	387	50.8					
Endophthalmitis	Present	12	75	4	25	0.886	0.099	2.425	0.846	6.949
	Absent	359	46.5	412	53.5					
RAPD	Present	23	71.9	9	28.1	2.523	0.000	12.466	5.378	28.896
	Absent	41	17	200	83					
Intravitreal foreign body	Present	154	57.9	112	42.1	0.479	0.002	1.615	1.198	2.175
	Absent	240	46.1	281	53.9					
Retinal foreign body	Present	69	50.7	67	49.3	0.062	0.743	1.064	0.735	1.540
	Absent	325	49.9	326	50.1					
Zone 3 injury	Present	344	30.9	154	69.1	2.344	0.000	10.424	7.293	14.899
	Absent	51	17.6	238	82.4					
OTS category 1	Present	248	86.4	39	13.6	2.726	0.000	15.270	10.353	22.522
	Absent	147	29.4	353	70.6					

n number of cases, *IVA* initial visual acuity, *FVA* final visual acuity, *PPV* pars plana vitrectomy, *RAPD* relative afferent pupillary defect, *B* regression coefficient, *OR* odds ratio (with 95% confidence interval), *CI* confidence interval (95%)

^aUnivariate analysis (binary logistic regression)

Contrary to this IOFB group in our study had a relatively favorable visual outcome. Land mine and broken glass injury have a statistically significant effect on final VA in

the current study ($p < 0.001$) (Table 1). The probable cause of this could be close distance injury and contusion damage due to severe blast effect of land mines.

Table 5 Prognostic variables on FVA in multivariate analysis

^a	<i>B</i>	<i>p</i>	OR	CI	
IVA 20/200>	2.173	0.000	8.784	4.785	16.126
OTS category 1	1.743	0.000	5.716	3.507	9.317
Zone 3 injury	1.108	0.000	3.027	1.903	4.815
Additional PPV surgery	1.047	0.000	2.849	1.897	4.279
Lens damage	0.478	0.022	1.613	1.070	2.431

IVA initial visual acuity, *PPV* pars plana vitrectomy, *B* regression coefficient, *OR* odds ratio (with 95% confidence interval), *CI* confidence interval (95%)

^aMultivariate analysis (binary logistic regression)

Although 89.5% of our cases were in 19–50 age group, the success rate was highest in 0–18 age group ($p = 0.005$). Owing to heterogeneity in age groups; types of injury, OTS category distribution, zone of the injuries vary between groups. We think the main cause of difference between age groups probably arising from disparities between three age groups.

Poor final VA in OGI correlates with the higher zone of the injury [11]. In a study of Soni et al, [12] which included only initial perception negative cases, they reported that all the cases primary enucleated had zone 3 injury. Knzayer et al. [13] reported that the best prognostic factor in zone 3 OGI is presenting VA. This study showed zone 3 injury has a crucial effect on final VA in OGI similar to ours.

Kuhn et al. [3] described OTS classification in ocular trauma to predict likelihood of final VA within 6 months. The prediction of final VA with OTS study [3] was not valuable in our study except for OTS category 5. This might be owing to relatively higher (69.3%) rates of our OTS category 1 and 2 cases, which already have a poor functional prognosis (Table 3).

Consistent with the previous reports [6, 9], additional surgeries (the timing of the surgery that were not performed in the first surgery session) had a negative effect in gaining satisfactory visual outcome in our study ($p < 0.001$). Pieramici [9] explained this with the fact that less-severe injuries tend to require less surgery. The opposite is also true that more severe injuries, with more subsequent complications, would require more surgery and carry a worse prognosis [9].

PPV affects final visual outcome positively in OGI [14, 15]. We also confirmed statistically significant beneficial (primary or additional) effect of PPV surgery on final VA success criteria when we compared our cases before and after PPV ($p < 0.001$). Interestingly, contrary to previous studies we found additional PPV procedure has a negative impact on predicting final VA in multivariate analysis ($p:000$, OR: 2.84 with 95% confidence interval) (Table 5). In a subgroup analysis of additional PPV cases, we detected 81.3% of cases were also had zone 3 injuries, which were already severely injured and had a relatively poor visual potential.

Although RAPD is one of the well-known prognostic values of OGI [3, 9], we did not find RAPD as an independent criteria in multivariate analysis. The possible cause of this might be due to a relatively higher rate of bilateral involvement in our cases. Similarly, endophthalmitis did not have a prognostic value either in univariate or multivariate analysis in our study. Though most of our cases (42.1%) were IOFB injuries, endophthalmitis rate (2%) was relatively low. Similarly, Erdurman et al. [16] reported no case of endophthalmitis related with improvised explosive devices in their study. This might be due to the sterilization effect of thermal injury (land mines, hand grenades etc.).

Another important result of our study was that lens damage was another factor affecting final VA in multivariate analysis. Jandeck et al. [17] argued that lens damage and cataract formation is a poor prognostic factor in predicting final VA in children because of aphakia. In a subgroup analysis, only 8.4% of lens damage cases are in pediatric age group. Interestingly 77.4% of lens damage group were in OTS category 1 and 2. In lens damage cases, the rates of OTS category 1 and Zone 3 involvement were 33.5% and 64.4%, respectively. We think the poor outcome in eyes with lens injury is caused by coexisting severe posterior tissue damage.

We are aware that though our case series include a long-time period of 18 years, retrospective and nonrandomized nature of the study is the weakness of this report. Moreover, possible treatment selection bias could change the results. Therefore, it is essential to conduct a prospective controlled study to describe strict criteria to guess visual prognosis in OGI.

To conclude, we report a large case series of OGI most of which were terror-related and had relatively severely injured eyes. In addition to well-known prognostic values we studied less-studied variables to predict final VA. We determined five main variables that predominantly affect final VA as initial VA < 20/200, OTS category 1, zone 3 injury, additional PPV surgery and lens damage.

Summary

What was known before

- Prediction of visual outcome in open-globe injuries was possible with using OTS variables.

What this study adds

- Initial VA < 20/200, OTS category 1, zone 3 injury, additional PPV surgery and lens damage might be potential variables to predict visual outcome besides OTS variables in open-globe injuries.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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