Glaucoma after open globe injury at a tertiary care university hospital in Central Saudi Arabia

Cumulative incidence and risk factors

Essam A. Osman, *MD, FRCS,* ***Nawaf Al-Fawaz,*** *MD,* ***Abdulla G. Al-Otaibi,*** *MD,* ***Samir M. Al-Mansouri,*** *MD,* ***Ahmed Mousa,*** *PhD,* ***Hani S. Al-Mezaine,*** *MD.*

ABSTRACT

الأهداف: دراسة عوامل حدوث الخطر ومعدل الإصابة التراكمى بالزرق بعد جروح العين المفتوحة.

الطريقة: أجريت دراسة استرجاعية على السجلات الطبية لجميع المرضى الذين تم تشخيصهم كحالات جروح عين مفتوحة ومن ثم خضعوا لعملية إصلاح أولية خلال الفترة من يناير 1996م وحتى ديسمبر 2011م فى مستشفى الملك عبد العزيز الجامعى، الرياض، المملكة العربية السعودية.

النتائج: خلال فترة ال 15 عاماً التى استعرضتها الدراسة ، تم تحديد 775 مريضاً من الذين خضعوا لعملية إصلاح لإصابات العين المفتوحة. وكانت نسبة الإصابة الكلية بينهم بالزرق 5.3% (41/775) بعد متوسط متابعة قدره (12±6.5) شهراً. وقد كشف تحليل المتغيرات الفردي عن عوامل الخطر الفعلية للإصابة بالزرق وهى: إصابة المنطقة الثانية p=0.027، والإصابات التى تخترق العين p=0.0008، وإصابات العدسة p=0.011، ونزيف الجسم الزجاجى p=0.002، ووجود جسم غريب داخل العين p<0.0001. بينما وقع المرضى في الفئة العمرية من 18عاماً وأكثر فى المنطقة الحرجة (p=0.054). وبتطبيق الإنحدار اللوجستي، وجد أن الإصابات التى تخترق العين p=0.019، وإصابة العدسة p=0.002، ونزف الجسم الزجاجى p=0.037 هي عوامل الخطر المعنوية.

خاتمة: ليس من المستبعد إصابة العين بالزرق بعد جروح العين المفتوحة. كما تعتبر إصابة المنطقة الثانية، والإصابات التى تخترق العين، وإصابة العدسة، ونزف الجسم الزجاجى، ووجود جسم غريب داخل العين أهم عوامل الخطر الفعلية للإصابة بالزرق بعد جروح العين المفتوحة.

Objectives: To investigate the incidence and risk factors of glaucoma after open globe injury (OGI).

Methods: The medical records of all patients admitted with the diagnosis of OGI at the Department of Ophthalmology, King Abdulaziz University Hospital, Riyadh, Kingdom of Saudi Arabia and had undergone primary repair from January 1996 to December 2011 were retrospectively reviewed.

Results: For the 15-year study period, 775 patients who underwent repair of an OGI were identified. The overall risk of post-traumatic glaucoma was 5.3% (41/775) with a mean ± SD follow-up period of 12±6.5 months. Univariate analysis revealed that Zone II injury (p=0.027), penetrating ocular injury (p=0.0008), lens injury (p=0.011), vitreous hemorrhage (p=0.002), and presence of intraocular foreign body (p<0.0001) were significantly associated with glaucoma. Age of more than 18 years was critical (p=0.054). Following logistic regression, penetrating ocular injury (p=0.019), lens injury (p=0.002), and vitreous hemorrhage were significant (p=0.037).

Conclusion: Glaucoma after OGI is not uncommon. Zone II injury, penetrating ocular injury, lens injury, presence of vitreous hemorrhage, and presence of an intraocular foreign body were significant risk factors for developing post-traumatic glaucoma.

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From the Department of Ophthalmology, College of Medicine, King Saud University, Riyadh, Kingdom of Saudi Arabia.

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Address correspondence and reprint request to: Dr. Essam A. Osman, Department of Ophthalmology, King Abdulaziz University Hospital, College of Medicine, King Saud University, PO Box 245, Riyadh 11411, Kingdom of Saudi Arabia. Tel. +966 507449080. Fax. +966 (1) 4775731. E-mail: essamaosman@gmail.com

Ocular trauma remains an important cause of preventable blindness globally.[1-3] Several risk factors are associated with visual loss caused by ocular trauma. Such factors may include; glaucoma, corneal scarring, lens injury, vitreous hemorrhage, retinal and choroidal detachments, and endophthalmitis. Increased intraocular pressure after repair is one of the well known complications, which may persist and require further management. The mechanism of developing glaucoma either goes through meshwork injuries, or inflammation, which may block the outflow of the aqueous humor, leading to secondary glaucoma. Consequently, the function of the trabecular meshwork may get recovered or decompensated.[4,5] Little is known regarding the risk factors of glaucoma after open ocular trauma in the literature.[6,7] In the current study, we aimed to evaluate the incidence and potential risk factors for developing glaucoma after repair of open globe injuries (OGIs) at a tertiary care university hospital in Riyadh, Kingdom of Saudi Arabia (KSA).

Methods. The search strategy of the literature was carried out using identified relative key words and targeting PubMed, EBSCO, OVID, and Google scholar. Search findings were retrieved, then filtered to select the more relative ones according to our objectives. The medical records of all patients admitted with the diagnosis of OGI, and had undergone primary repair from January 1996 to December 2011 at the Department of Ophthalmology, King Abdulaziz University Hospital, Riyadh, KSA were retrospectively reviewed. In the current study, an OGI was defined as any traumatic, full-thickness wound of the globe. Patients were excluded for the following reasons: undergoing primary repair elsewhere before presentation; presenting with a diagnosis of endophthalmitis; and undergoing primary enucleation for an irreparably traumatized eye. The location and extent of the OGI (cornea only) was identified as Zone I, corneoscleral within 5 mm of the limbus (Zone II), and corneoscleral extended more than 5 mm beyond the limbus (Zone III). Medical records were reviewed to determine patients' demographics such as: visual acuity at presentation; type, extent, and location of ocular injury; mechanism of the injury (blunt, sharp, missile); presence of an intraocular foreign body (IOFB); lens injury and vitreous hemorrhage and prolapse; during the follow-up period. Patients included in this study were classified into one of 3 categories according to the time of onset of post-traumatic glaucoma: 1) early stage (≤one month after ocular trauma); 2) intermediate stage (2-6 months); and 3) late stage (>6 months).[8] This study was registered with the institutional review board and adheres to the tenets of the Declaration of Helsinki. Approval was obtained from the Research and Ethics Board of the College of Medicine, King Saud University (approval #E-11-501).

Statistical analysis. Data were collected and stored using a specifically designed Microsoft Excel 2007® sheet. Data were then reviewed, managed, and cleaned for analysis with Statistical Package for Social Sciences version 19 (IBM, Chicago, IL, USA) and MedCalc version 11.6 (MedCalc Software, Mariakerke, Belgium). The chi-square test was performed to investigate the association between different potential risk factors and the occurrence of glaucoma as a complication of interest (Fisher exact test whenever indicated). The student's t-test was used to compare means between glaucoma and non-glaucoma cases. A $p<0.05$ indicated statistical significance. Moreover, a binary logistic regression was conducted to adjust for interaction and other confounding variables where all significant variables were introduced into the model.

Results. The records of 818 patients who had undergone repair of an OGI were reviewed. Of these, 43 records were excluded because of missing or incomplete data. Of the 775 patients included in the current study, 675 (87.1%) were males and 100 (12.9%) were females with a mean ± standard deviation (SD) age of 25.7 ± 15 years (range: 1-84 years; median - 27 years). We estimated the overall cumulative rate of post-traumatic secondary glaucoma at 5.3% (41/775) over a mean follow-up period of 12 ± 6.5 months (range: 3 months to 13.8 years). In the univariate analysis, the development of post-traumatic glaucoma was significantly associated with Zone II injury ($p=0.027$), penetrating ocular injury ($p=0.0008$), lens injury ($p=0.011$), presence of an intraocular foreign body ($p<0.0001$), and presence of vitreous hemorrhage ($p=0.002$), whereas age greater than 18 years was critical ($p=0.052$). Logistic regression analysis revealed that the following risk factors were significantly associated with the development of post-traumatic glaucoma: penetrating ocular injury (odds ratio [OR] - 3.5; 95% confidence interval [CI]: 1.41-8.9; $p=0.019$), vitreous hemorrhage (OR - 2.4; 95% CI: 1.53-6.2; $p=0.037$), and lens injury (OR - 2.1; 95% CI: 1.56-7.7; $p=0.002$) (**Table 1**). During

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Table 1 - Univariate analysis to assess different factors associated with post-traumatic glaucoma (N=775).

Variable	n (n=41)	(%)	No glaucoma (n=734)	Total	*P*-value	95% confidence intervals (LCL - UCL)
Age, years						
≤18*	8	(3.1)	251	259	0.052	0.952 - 5.449
>18	33	(6.4)	483	516		
Gender						
Male*	37	(5.5)	638	675	0.537	0.182 - 2.067
Female	4	(4.0)	96	100		
Vision						
≤HM*	18	(6.9)	243	261	-	
CF	8	(4.3)	176	184	0.614	0.226 - 1.525
≥20/200	15	(4.5)	315	330	0.216	0.295 - 1.383
Mechanism of injury						
Blunt*	3	(5.6)	51	54	-	
Sharp	24	(4.5)	505	529	0.730	0.233 - 4.336
Missile	14	(7.3)	178	192	0.998	0.353 - 7.526
Type of trauma						
Penetrating	35	(4.7)	717	752	0.0008	0.048 - 0.458
Perforating*	6	(26.1)	17	23		
Extent of trauma						
10 mm*	34	(5.0)	652	686	-	
10-20 mm	6	(7.7)	72	78	0.285	0.529 - 4.027
>20 mm	1	(9.1)	10	11	0.435	0.0429 - 4.027
Location of trauma						
Limited to cornea (Zone I)*	21	(4.1)	495	516	-	
Corneoscleral not extended (Zone II)	19	(7.9)	220	239	0.027	1.012 - 4.063
Corneoscleral extended (Zone III)	1	(5.0)	19	20	0.574	0.0285 - 8.594
Lens injury						
Yes	19	(8.5)	204	223	0.011	1.121 - 4.441
No*	22	(4.0)	530	552		
IOFB						
Yes	5	(0.8)	634	639	<0.0001	0.008 - 0.058
No*	36	(26.5)	100	136		
Vitreous hemorrhage						
Yes	7	(15.6)	38	45	0.002	1.320 - 9.382
No*	34	(4.7)	696	730		
Vitreous prolapse						
Yes	1	(5.6)	17	18	0.998	0.025 - 7.707
No*	40	(5.3)	717	757		

*reference group in the analysis. HM - hand movement, CF - counting fingers, IOFB - intraocular foreign body, LCL - lower confidence interval limits, UCL - upper confidence interval limits

the early stage (≤one month), high intraocular pressure (IOP) developed in 11 patients (26.8%) because of unremoved lens particles in 6 patients (14.6%) due to inflammation, and in 3 patients (7.3%) due to hyphema. During the intermediate phase (2-6 months), synechial angle closure was the recognized cause in 9 patients (22%), ghost cell in 3 patients (7.3%), and unremoved lens particles in 2 patients (4.9%) of those who developed post-traumatic glaucoma. During the late stage (>6 months), the IOP gradually rose in 4 patients (9.8%) because of angle recession, and in 3 patients (7.3%) because of synechial angle closure (**Table 2**). At the last follow-up visit, all 41 patients who had developed post-traumatic secondary glaucoma underwent gonioscopy. This procedure revealed that 23 patients (56.1%) had open-angle glaucoma, 14 patients (34.1%) had closed-angle glaucoma, and 4 patients (9.8%) had angle recessions.

Discussion. In this retrospective cohort study, we determined the overall incidence of glaucoma after open ocular injury to be 5.3%. The risk factors significantly associated with the development of glaucoma in the present study were: Zone II injury; penetrating ocular

Table 2 - Causes and time of onset of post-traumatic glaucoma.

Stage	Causes of glaucoma
Early (≤one month) (n=20)	Unremoved lens particles (n=11) Inflammatory (n=6) Hyphema (n=3)
Intermediate (2-6 months) (n=14)	Synechial angle closure (n=9) Ghost cell (n=3) Unremoved lens particles (n=2)
Late (>6 months) (n=7)	Angle recession (n=4) Synechial angle closure (n=3)

injury; lens injury; presence of vitreous hemorrhage; and presence of an intraocular foreign body during the follow-up period.

The incidence of post-traumatic glaucoma is unpredictable in closed and open eye injuries. Several studies have estimated the incidence rate after a closed eye injury to be between 3.4 and 19%. Apparently, very few studies have estimated the incidence of glaucoma after a penetrating ocular injury. Based on data from the United States Eye Injury Registry (USEIR), Girkin et al[6] determined the risk of developing post-traumatic glaucoma after a penetrating eye injury to be 2.67% over a 6-month follow-up period. In our study, the incidence of post-traumatic glaucoma was 5.3%. Recently, Turalba et al[7] estimated the prevalence at 17%, however according to their criteria, among their series, those with ocular hypertension ≥22 mm Hg at one visit and treated were included, which may have overestimated their prevalence. Additionally, although our incidence is higher than Girkins',[6] this may be explained by our longer mean follow-up duration (12 ± 6.5 months).

Glaucoma that occurs after open eye injuries tends not to follow any predictable patterns and is most probably multifactorial in origin.[9] For example, it may develop following inflammation, which can lead to synechial angle closure, particularly in patients with a shallow or flat anterior chamber. Other risk factors for developing glaucoma following an open eye injury include the alteration of the trabecular meshwork caused by blood cells inflammatory debris, lens particles, and ghost cells associated with long-lasting vitreous hemorrhage.[9] In agreement with what has been reported in the USEIR study,[6] we found a significant association between the development of glaucoma, lens injury, and presence of vitreous hemorrhage during the follow-up period. Although age was not explicitly significant, its probability value was quite critical (p=0.054), which reflects a high probability of reaching the significance level if the sample size were slightly increased. This finding is highly supported by the literature,[6,7] where an association between traumatic glaucoma and an increase in age is expected because the trabecular meshwork might be more compromised in this age group. In addition, it is well known that the incidence of primary open-angle glaucoma (POAG) is higher in the healthy elderly population.[10,11] Girkin et al[6] detected an association between glaucoma and other risk factors reported here (poor visual acuity at presentation, lens injury, presence of vitreous hemorrhage) might be explained by increased severity of trauma because these clinical signs are commonly observed in more serious ocular injuries. Moreover, Turalba et al[7] found that the increased age, hyphema, lens injury, and Zone II injury are potential risk factors for developing ocular hypertension after OGI.

Additionally, Girkin et al[6] found no significant association between the presence of retained IOFB and glaucoma. This disagreement with our study findings may be explained by the differences in the removal time of IOFB. Our clinical protocol involved the removal of the IOFB one to 2 weeks after primary repair, whereas the protocol followed by Girkin et al[6] involved the removal of most IOFB during the initial examination, if detected. Turalba et al[7] did not look for IOFB as a risk factor due to exclusion of a significant number of patients with IOFB from their study. One possible reason for such a positive association in our study is the longer duration (one to 2 weeks) of ocular retention of foreign bodies containing ferrous metals, which may lead to siderosis and iron staining of the trabecular structures.[6] However, this explanation seems unlikely because the period of time (one to 2 weeks) is rather short for siderosis to develop.

The current study have faced a number of limitations as per its retrospective nature, which hindered the collection of all required information, and the relatively small number of cases. In the future, a prospective study with trauma registry program might enable better in depth understanding of the risk factors for glaucoma and other post-traumatic ocular disease

In conclusion, we determined the incidence of glaucoma after open ocular injury to be 5.3%. Several baseline risk factors were identified that were significantly and independently associated with the development of glaucoma, including Zone II injury, penetrating ocular injury, lens injury, presence of vitreous hemorrhage, and the presence of an intraocular foreign body during the follow-up period. Patients with OGI must be carefully observed, and special attention should be paid to any early signs of glaucomatous changes, particularly in patients who are considered at high risk.

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