Global Journals LaTeX JournalKaleidoscope™
Artificial Intelligence formulated this projection for compatibility purposes from the original article published at Global Journals. However, this technology is currently in beta. *Therefore, kindly ignore odd layouts, missed formulae, text, tables, or figures.*

Volume XVII Issue V Version I

Francis Kwasi Obeng

Received: 6 December 2016 Accepted: 4 January 2017 Published: 15 January 2017

Abstract

Background: Pellets are destructive when they enter into the eye. They are categorized into lead and non-lead based on substances they are manufactured with. The latter, are usually made of steel, tin or plastic materials. Lead pellets (LP) are the most widely used due to their appropriate weight, targeting accuracy, malleability, density and affordability. According to their head shape, they are classified into wadcutter, pointed, round-nose and hollow-point pellets.Although there are several articles on ocular trauma, none has focused into detail on ocular pellet gunshots at Northern India. To fill in this gap in knowledge, we evaluated all the negative impacts of pellet to the eye in a cross section of patients from Kashmir, a conflict zone in Northern India.Aim: To assess detrimental effects of ocular pellet injury and their management in a cohort of Indian patients who visited our hospital from Kashmir.

Index terms— eye pellet injury, ocular pellet, lead toxicity, intraocular foreign body.

1 I. Introduction

ellets are small-hard-ball-hour-glass-shaped projectiles which travel at high velocity and temperature when fired from an air gun. Ocular LP injury can cause not only primary eye anatomical and functional morbidities but also secondary negative impact on almost all the systems and organs in the body. 1 According to United State Centers for Disease Control, the normal blood level of lead above which it induces secondary unwanted systemic effects is 5 and 10ug/dl in children and adults respectively. **??** It is important to emphasize that lead may demyelinate axons of the nerve fibre layer and consequently bring about severe visual impairment. **??** A report from the United State Eye Injury Registry Database has recently confirmed that 6% of all ocular injuries are imputable to Ball Bearing and pellet guns and constitutes the most common gun injury in the emergency room. 4,5 Many have been the extensive publications on gun related trauma to other organs in the body but the literature on ocular and orbital pellet injuries is comparatively inadequate. 6,7,8,9,10 Firearm injuries are classified into 3 groups: penetrating, perforating and avulsive. **??**1 Penetrating injuries are caused by low velocity projectiles and have small entrance and exit wounds although some of them may not have exit wounds at all. Perforating types, however, have small entry and comparatively large exit wounds and are found within the orbit or beyond due to the high velocity with which the projectiles pass through the eye. Avulsive injuries cause tearing of tissues some of which may be lost. The severity of ocular injury depends on several factors: type and shape of pellet, its velocity, distance from which the patient is shot and tissue resistance. 12,13 Research has shown that perforating injuries with damage to posterior segment structures have more guarded prognosis especially if the attending ophthalmologist is not an experienced retinal specialist. 14,15,16 The negative impact which results from OPI may be so detrimental that more emphasis should be laid on prevention and subsequent reduction in its occurrence rate. 17,18,19,20,21 The purpose of this study was to assess effects of pellet injury to the eye and its management in a cohort of Indian patients who visited our hospital from Kashmir, a must-visit-beautiful-tourist-attraction area sandwiched between India and Pakistan over which citizens of both countries have been at logger heads for ownership for several decades.

2 II. Material and Method

Medical records of all 39 consecutive patients who presented to our hospital with OPI to the posterior segment of the eye and operated upon between 2014 and 2016 were collected and retrospectively analysed. Seven patients were excluded from the study because they were followed up for less than 1 month or lost to follow up. All surgeries were performed by 3 experienced vitreoretinal surgeons. Institutional ethical approval was required for this research and in a wider magnitude, the tenets of Declaration of Helsinski, applied in an attempt to respect human rights of patients who participated in the study. Collection of demographics, type of injury, choice of management, complications, requirement for further surgery and final visual outcomes are reported.

The preoperative information obtained in all our patients were age, sex, laterality, time interval between injury and presentation, type of injury, pellet impact sites, BCVA at presentation and last visit, intraocular pressure (IOP), crystalline lens status and extent of posterior segment injury. Patients whose ocular media were not transparent underwent B-scan imaging. However, those who gave history of OPI and B-scan did not reveal any intraocular foreign body automatically became candidates for Computed Tomography (CT) scan of orbit, paranasal sinuses and brain in an attempt to look for extraocular nidus of the pellet.

Surgical information collected included type of anesthesia, period between primary repair and first major procedure, number of surgeries, need for lensectomy, removal of pellet and type of retinopexy applied to the entry and exit wound sites. More data collected focused on use of tamponade, buckle, complications of surgeries, use of antibiotics and steroids.

Keratometry measurement and axial length of the contralateral better eye were utilized to calculate intraocular lens (IOL) power of the injured eye. The IOL power was decreased by 2 dioptres to get the final value in patients who had circumferential buckling due to approximate same power of myopic shift induced by a 1mm increase in axial length of the globe in those patients with the aim to preventing anisometropia and aniseikonia. 22 The Snellen BCVA was converted into logarithm of the minimum angle of resolution (logMAR) units for statistical analysis. Patients whose visual acuities were hand motion were assigned the equivalence of 1.7 logMAR units. The x 2 test is used for determining relationships between categorical variables, and the paired t test was used for normally distributed variables. All tests were considered to be statistically significant if the p value was 0.05 or less.

3 III. Results

33 eyes of 32 patients (30 males and 2 females) were included in the study. Mean age at presentation was 19.9+5 years (range 10-35 years) with a mean postoperative follow up period of 6.6+4 months (range 1 to 18 months). Table 1 shows a summary of preoperative data. The average period between injury and presentation to our hospital was 1.44 days (range 1 to 3 days). At presentation BCVA ranged from light perception to 6/12. Entry sites were predominantly corneal (90.91%; n=30) and the rest were scleral (9.09%; n=3). Our most common presenting clinical feature was vitreous haemorrhage (72.73%; n=24), followed by cataract (45.45%; n=15), rhegmatogenous retinal detachment (30.30%; n=10) and hyphaema (24.24%; n=8). Owing to lack of transparency of ocular media, B-scan ultrasonography (BSU) was performed on 27 eyes (81.82%) for appropriate assessment of posterior segment. CT scan of orbit, paranasal sinuses and brain was used to assess extraocular location of pellet in 5 (15.15%) eyes which sustained perforating injury all of which were caused by pointed-headed pellets. On the other hand, the 28 eyes (84.85%) which had penetrating injury were caused by round-headed pellets. In all, site of impact at the macula occurred in 9 eyes (27.27%) whilst the remaining 24 (72.73%) eyes had extra-macular retinal injuries. The macular-sparing eyes had better visual outcomes.

Primary repair of entry wound together with intravitreal injection of vancomycin, ceftazidime and dexamethasone was done on first day of reporting to our centre after fungal etiology was ruled out in all Volume XVII Issue V Version I All the patients had 20 gauge vitrectomy under local anaesthesia. Concurrent lensectomy was performed in 15 eyes (45.45%) all of which had correction of aphakia with posterior chamber scleral fixation of intraocular lenses (PCSFIOL) at least 8 weeks after the lensectomy. This method of aphakia correction was chosen because these eyes had had traumatic capsular rupture and zonular dehiscence from the pellet. Round-headed pellets were removed from the globe in all the 28 penetrating cases and retinopexy, utilized around breaks, entry and exit wound points involving the retina. Anterior retinal cryotherapy (ARC) was applied around anterior breaks whilst endolaser photocoagulation was utilized around posterior tears. Out of the 10 cases of retinal detachment, 7 (70%) had pars plana vitrectomy (PPV) with fluid-air-exchange (FAE), endolaser (EL) and silicone oil (SO) as tamponade owing to associated inferior breaks but the remaining 3 (30%) were treated with belt buckling (BB), PPV, FAE, EL and sulfur hexafluoride (SF_6) gas due to multiple superior breaks in different quadrants. The 3 eyes with scleral site of entry had anterior retinal breaks without detachment. They all had PPV, pellet removal and ARC.

At the end of surgery all patients received subconjunctival dexamethasone and subsequently, use of combination of topical steroid and antibiotic. Oral treatment given were ciprofloxacin and non-steroidal anti-inflammatory drugs.

11 eyes had complications from the initial vitreoretinal surgery (VRS) : 5 (45.45%) ocular hypertension from SO, four (36.36%) epiretinal membrane (ERM) formation and 2 (18.18%) recurrence of retinal detachment (RD) with retinal incarceration as shown in table 2. In total 8 secondary VR procedures were performed to manage the complications: two cases of silicone oil tapping, 4 eyes had ERM/internal limiting membrane peeling (ILMP) and 2 other eyes were managed with BB, revitrectomy, retinectomy, endolaser and SO injection. The time range between the first and second VR surgeries was 5 to 60 days with a mean of 41.38 days. All patients who had SO

injection had it removed 4 weeks after the initial surgery. Postoperative complications and management are as found in table 2.

4 Table 2: Post-Operative Complications and Management

At last follow up, 18 (54.55%), 14 (42.42%) and 1 (3.03%) eyes had had improvement, maintenance and worsening of their BCVA respectively with visual acuity ranging from light perception to 6/12. Out of the 14 eyes which maintained their visual acuities, 12 had final BCVA of light perception and the remaining 2 had counting fingers. The impact site was macular involving in those who had maintenance or worsening of their presenting visual acuities. The mean difference between final BCVA and presenting visual acuity was 0.07 + 1.0 logMAR units which was statistically significant. (p=0.0018) This is shown in the graph pad below with its corresponding table.

5 Graph Pad Table

All values are expressed as mean ± standard deviation. * P < 0.05, ** P< 0.01, *** P< 0.001 Graph pad software version 5.0 was used to analyse data. Numerical data was compared using t test.

6 IV. Discussion

a) Characteristics of Pellets Pellets have 3 main parts: Front, middle and rear. **??**3 Their shape is such that they have a smaller middle and larger front and rear diameters, a feature which makes them perform their function with perfection and has been termed diabolo. **??**3 They can also be light or heavy according to their weight. A pellet is heavy when its weight is above the average (58mg). 24 Those made of lead, like all those removed from our patients' eyes, are heavy. Owing to the fact that velocity of pellets are directly proportional to their weight, LP are heavier and therefore have faster speed, a property which is known as high ballistic coefficiency. **??**5 aerodynamic property. **??**6 Being capable of travelling at a velocity of 1200 feet per second, 27 a pellet causes more injury the closer it is to its target. Pointed pellets have more perforating effects than the other types. **??**8 In our study all the perforated injuries were caused by pointedheaded whilst the penetrating injuries were caused by round-headed pellets.

7 b) Acute Clinical Features

Being difficult to detect sometimes, foreign bodies may cause serious damage to intraocular and periocular structures. In order not to miss the diagnosis, a history of OPI should always be present bearing in mind that they most frequently occur in males between the ages of 11 to 30 years according to Finkelstein et al. 29 In our hospital out of 32 patients who were affected, 30 (93.75%) were males and the other 2 (6.25%) were females. The age group mostly affected in our study was between 10 to 35 years with a mean of 19.9+5 years. These findings are similar to what has been detected by Finkelstein and colleagues. Clinical features of ocular lead pellet injuries may be acute or chronic. Acute injuries, undoubtedly, may include but not limited to corneoscleral laceration, hyphaema, cataract, vitreous hemorrhage and retinal detachment. **??**0 We had similar findings in our study with vitreous hemorrhage being the most common.

OPI is generally a mono-ocular problem but it may be bilateral, as indicated by Assaf et al, depending on direction of spread of the pellets. 20 In our study, out of the 32 patients only 1(3.13%) had bilateral impact making it a rare finding.

8 c) Chronic Clinical Features

About 90% of lead in the body is stored in the bones for as long as 30 years, a period during which it can cause systemic and ocular toxicity. **??**1 In our case series there were 5 eyes (15.15%) which had lead pellets in the orbit, a bony cavity which could easily absorb and store lead to cause toxicity.

Although lead poisoning can affect all the systems and cause a very wide range of morbidities in the body, the most common systemic effect is arterial hypertension. **??**1 Ocular manifestations of lead poisoning include optic neuritis, 32 nyctalopia, 33 and cataractogenesis. 34 Optic neuritis is the most common ocular manifestation. **??**1 A study published by Fox and Kats has shown that lead can increase rod outer segment calcium concentration, decrease rhodopsin content per eye and consequently end up in night blindness confirmed on electroretinogram as reduction in scotopic a and b waves. 33 Bushnell et al, in an attempt to find out why rods and not cones are predominantly affected, conducted a research the conclusion of which was that lead causes demyelination of the central nervous system and since rods far outnumber cones, the former are more prone to the damage. 35 In the research published by Schaumberg et al, 36 it was categorically stated that the higher the bone concentration of lead, the more the probability of cataract development. According to Neal et al, lead from bone can enter the lens to disrupt its proteins and glutathione metabolism all of which can hinder calcium homeostasis and form cataract. 37 Albeit we have not yet found any manifestations of lead poisoning in our patients, we are still following our patients up for a period of 30 years with the aim to publishing a prospective study whose aim it is to monitor for effects of lead toxicity.

9 d) Diagnostic Imaging

Being an ancillary test without which the presence, location, material, size and number of foreign bodies cannot be determined, diagnostic imaging (DI) has become the sine qua non in current management of ocular and peri-ocular foreign bodies. It is also a useful tool for the surgeon to have a preoperative surgical plan. B-scan ultrasonography (BSU), computed tomography scan (CTS), plain radiography (PR) and magnetic resonance imaging (MRI) are the options available although they have their advantages and disadvantages. 38 i. B-Scan Ultrasonography Albeit there is relative contraindication to its use in ruptured globe due to probability of vitreous content extrusion, [38][39][40] BSU is the main DI modality we use in our patients majority of whom had penetrating injury (n=28 eyes; 84.85%). We did not get any case of vitreous loss from the procedure. Its merit is exhibited by its high sensitivity in finding vitreous hemorrhage, retinal and choroidal detachments setting the pace for rapid change in the surgical management of the affected eye should the need arise. **??**1 Its main demerit is that it is associated with inter-examiner image quality and interpretation variations; thus the intraocular pellet could be totally missed. 39 ii. Computed Tomography Scan If the pellets are extraocular, CTS of orbit, paranasal sinuses and brain using thin axial and coronal view slices (0.625-1.25mm) is the best DI. 40 It can detect foreign bodies (FB) which are even less than 0.06mm in size with sensitivity of more than 65%. 39 It helps in diagnosis of bony fractures and intracranial extension of the FB. 39 Having a distinguishing property ascribable to its differences in signal intensity, it can differentiate between various materials with plastic and wood appearing hypodense in direct contrast to hyperdense images of lead pellet, graphite, iron and glass. 38,39 On not finding any FB on BSU in patients who had sustained pellet injuries to their eyes in our hospital (n=5 eyes; 15.15%), we requested for CTS of orbit, paranasal sinuses and brain using thin axial and coronal view slices (0.625-1.25mm). In all the 5 cases, the pellets were in the orbit with air pockets around them. In 1 eye there was a pellet at the lateral wall of the lateral rectus but extraocular movements were normal.

Safe though it may be, it releases radiation to patients. Its other disadvantages include occasional obscuration by streak artifacts by metals like lead pellets and high cost to poor patients. 38 iii. Plain Radiography Being readily available and cheap, PR is used in poorer patients who cannot afford payment of previously mentioned DI tools. Its sensitivity rate in detection of ocular and peri-ocular FB is as low as 40%. 38,39 Apart from its inability to distinguish between different types of foreign bodies, it easily misses radiolucent objects like wood and plastic. **??**1 As a policy in our center, we never request for PR due to its low sensitivity. There were 5 patients in this study who could not pay for BSU but we did it at no cost for them just to augment our diagnostic yield.

iv. Magnetic Resonance Imaging Owing to the magnetic field it creates with metallic FB (MFB) like lead pellets (LP), MRI may bring about migration of the MFB and destruction of tissues which may end up in premature blindness, a reason which makes this modality of DI a contra-indication in MFB. 39 It is therefore paramount that appropriate history is taken from the patient to avoid requesting for MRI in an attempt to find extraocular locus of LP. 40 In our hospital, we never use it as a DI test in patients with history of MFB.

10 e) Intravitreal Injections

Although some researchers never recorded endophthalmitis after OPI due to the characteristic high temperature and speed with which pellets travel, **??**0 Kara et al did establish in their study that shot gun wounds can be infected by micro-organisms. 42 This fact was confirmed when other authorities substantiated the fact that some bacteria can resist high velocity bullets. 43,44 Organisms frequently found in traumatic globe injuries include Bacillus cereus, Staphylococcus and polymicrobes according to Fulcher et al. 45 In our hospital, just after primary repair of ocular pellet injury we routinely administer intravitreal vancomycin, ceftazidime and dexamethasone to prevent or combat against Gram positive infections, Gram negative toxins and inflammation respectively when fungal etiology has been ruled out with microscopy. Should the test reveal fungal micro-organisms, we usually treat the eye with intravitreal variconazole or amphotericin B instead of the steroid.The purpose is to prevent endophthalmitis. In this study, none of our patients developed endophthalmitis, a success which we attribute to the prophylactic measures.

11 f) Surgical Treatment

A study published in Ireland showed that 71.43% of eyes which were managed with only primary repair after OPI developed phthisis bulbi whereas 100% of eyes which had primary repair and vitrectomy within 1 week of repair had better visual outcomes. 21 In our centre all the patients had primary repair of the entry wound with intravitreal injections and the first major vitreoretinal surgery performed within 12 to 24 hours after the repair.

In our case series the most common clinical feature was vitreous hemorrhage (VH) and therefore it is logical that all the patients were managed with simple vitrectomy. We applied additional procedures like belt buckling when there were multiple anterior breaks in different quadrants, cryopexy around breaks, removal of foreign body if it was intraocular, retinectomy of incarcerated retina, use of internal tamponade and lensectomy depending on the presentation. Our rationale behind vitrectomy was not only to help in removal of the pellets and salvage the injured eye but also clear VH and scaffolds on which contractile fibroblasts could settle and multiply.

Although Weichel et al advocate for the use of chorioretinectomy in perforating injuries, 46 we never used it due to the possibility of causing severe damage to the surrounding photoreceptors and their nutrition from the underlying choriocapillaries and retinal pigment epithelium. The removal of pellet from the orbit in perforating ocular injury depends on their location, composition and impairment they cause. 29,45,47 In addition, their removal can cause severe damage to the orbital contents. 29,47 At our centre, since none of the 5 pellets in the orbit had any complications, we only observed them without removal till the last review and they were all well tolerated, a conclusion which was also reached by Ho et al in whose publication 43 patients with retained metallic orbital foreign bodies were followed up for 63 years by only observation and at the end of the period, all the MFB were well tolerated. 47

12 Indications

for surgical extraction include complications like compressive optic neuropathy, orbital hemorrhage, pain, infection and motility restriction. 41

13 g) Second Major Operations

Seven eyes had silicone oil removal (SOR) 4 weeks after the initial vitreoretinal surgery, 2 eyes had SO tapping 4 days after the main surgery, 8 eyes had management of surgical complications at different periods and 15 eyes had PCSFIOL 8 weeks after the lensectomy. On the average an eye with OPI in our hospital undergoes 3.56 + 1.93 number of ocular surgeries to achieve the utmost anatomical and visual outcomes, a conclusion which has also been reached by other authorities in OPI. ??0 Having had 31.8% of eyes which previously had intraocular foreign body (IOFB) developing proliferatve vitreoretinopathy (PVR) after vitrectomy in the Eye Injury Vitrectomy Study, Feng et al concluded that PVR is an indication for secondary major surgery. 48 The weakness of that study was that the researchers did not specify the chemical composition of the IOFB. In our centre, however, we did not get PVR after the first major vitreoretinal surgery and since all our pellets were lead-rich, it might create a scientific question on whether lead is PVR-protective which can only be answered with another research paper looking into association between types of IOFB and PVR , an academic future discovery which goes beyond the scope of this document.

14 h) Prognostic Factors and Outcomes

Anterior segment limited injuries have better anatomical and visual outcomes than those which extend to the posterior segment. 17,18,19,49 The more the kinetic energy of the pellet, the more damage it causes to the posterior segment structures. 15, ??7 Several studies have substantiated that a pointed pellet with high ballistic coefficiency and aerodynamic property has the potential to travel at a faster speed to cause perforating injury which, if not managed properly by an expert, results in very poor prognosis. 14,15,16 In our hospital, however, all the 9 eyes which had macular involvement had presenting and final BCVA of light perception. This finding makes us believe that contrary to what other researchers have revealed, macular involving damages, whether penetrating or perforating, irrespective of head shape of the pellet and expertise of the vitreoretinal surgeon, generally have guarded prognosis.

15 i) Limitations

Retrospective nature, single centre, 3 vitreoretinal surgeons and comparatively less number of participants constitute the major limitations of our study.

16 j) Summary

OPI is not uncommon at conflict zones of the world. Having several patterns of presentation, its management depends on the diagnosis which in turn is arrived at through appropriate history taking, examination and ancillary tests. Should the pellet be lead-made and orbital, it is not enough to treat only the eye. The management should encompass decades of follow up looking for evidence of systemic and intraocular lead toxicity. Several factors though there are in determining the final visual outcomes after OPI, the best is the reporting visual acuity even in the hands of the most experienced vitreoretinal surgeon. Prevention is the way forward.

Conflicts will never end in any part of the world. Government policy makers, however, can help prevent severe visual impairment by using other methods rather than pellets in casual settlement of conflicts. [1] [2]

[2]Volume XVII Issue V Version I © 2017 Global Journals Inc. (US) Year 2017

1

Number of cases	32 patients, 33 eyes
Gender	30 males, 2 females
Age	Average 19.9+5 years (10-35) years
Laterality	16 left, 15 right, 1 bilateral
Days from injury to primary repair	25 patients within 24 hours, 7 patients within 72 hours
Type of injury	5 perforating, 28 penetrating, 0 avulsive
Site of entry	30 corneal, 3 scleral
Perforating exit site	3 macular, 2 between arcades
Penetrating impact site	6 macular, 10 juxtamacular, 7 juxtapapillary, 3 equatorial, 3 scleral wound, 1 optic nerve head
Visual acuity at presentation	12 light perception, 8 hand motion, 7 counting fingers, 2 6/36, 1 6/24, 3 6/12
Anterior segment	8 hyphema, 15 cataract
IOP at presentation	Average 7 mmHg
Posterior segment	27 no view, 24 vitreous hemorrhage

Figure 1: Table 1 :

Management of Ocular Pellet Injury

COMPLICATION	NUMBER OF EYES (%)	TREATMENT
Ocular Hypertension from silicone oil	5 (45.45)	3 resolved on antiglaucoma medications, 2 had silicone oil tapping
ERM Formation	4 (36.36)	ERM/ILMP
Recurrent RD + Retinal incarceration	2 (18.18)	BB + revitrectomy+retinectomy+laser+SO
Total	11 (100)	D D D D) K (

PRESENTING VISIUAL ACUITY	FINAL BEST CORRECTED VISUAL ACUITY	P VALUE
0.12 ± 0.12	0.19 ± 0.21	0.0018

Figure 2:

.1 Declaration of Conflict of Interests

The authors declared no conflict of interest with regards to the research, authorship and publication of this article.

.2 Funding

The authors did not get any financial support for the research, authorship and publication of this article.

[Williams and Wilkins] , Lippincott Williams , & Wilkins .

[Fournier et al. ()] , D Fournier , M Cherifi , A Salvanet-Bouccara , F Forestier , J Feys . *Ophtalmologie* 1989. 3 (4) p. . (Eye injuries due to pellet guns. Apropos of 7 cases. Ref list)

[Finkelstein ()] , M Finkelstein . *Ophthalmology* 1997. 104 (1) p. .

[Lagalla ()] , R Lagalla . *Eur Radiol* 2000. 10 (8) p. .

[Fulcher ()] , T P Fulcher . *Ophthalmology* 2002. 109 (3) p. .

[Assaf et al. ()] , E Assaf , H Emadisson , K Bendeddouche , F Forestier , A Salvanet-Bouccara . *J Fr Ophtalmol* 2003. 26 (9) p. . (Pellet guns: a persistent threat to eyes. Ref list)

[Ho ()] , V J Ho . *Opthal Plast Reconstr Surg* 2004. 20 (3) p. .

[Kubal ()] , W S Kubal . *Radiographics* 2008. 28 (6) p. .

[Pinto ()] , A Pinto . *Semin Ultrasound CT MR* 2012. 33 (5) p. .

[Roden et al. ()] 'A five-year survey of ocular shotgun injuries in Ireland'. D Roden , P Cleary , P Eustace . *Br J Ophthalmol* 1987. 71 (6) p. . (PMC free article. Ref list)

[Schaumberg et al. ()] 'Accumulated lead exposure and risk of age-related cataract in men'. D A Schaumberg , F Mendes , M Balaram , M R Dana , D Sparrow , H Hu . www.rima.org/web/medline_pdf/Jama_2750.pdf *JAMA* 2004. 292 (22) p. .

[Schaumberg et al. ()] 'Accumulated lead exposure and risk of age-related cataract in men'. D A Schaumberg , F Mendes , M Balaram , M R Dana , D Sparrow , H Hu . www.rima.org/web/medline_pdf/Jama_2750.pdf *JAMA* 2004. 292 (22) p. .

[Advisory Committee On Childhood Lead Poisoning Prevention (ACCLPP)". CDC (2012)] *Advisory Committee On Childhood Lead Poisoning Prevention (ACCLPP)". CDC*, https://en.wikipedia.org/wiki/Lead_poisoning2 May 2012. 18 May 2012.

[Kratz et al. ()] 'Airsoft gun-related ocular injuries: novel findings, ballistics investigation, and histopathologic study'. A Kratz , J Levy , D Cheles , Z Ashkenazy , E Tsumi , T Lifshitz . *Am J Ophthalmol* 2010. 149 (1) p. . (Ref list)

[Wolf et al. ()] 'Autosterilization in low-velocity bullets'. A W Wolf , D R Benson , H Shoji , P Hoeprich , A Gilmore . *J Trauma* 1978. 18 (1) p. 63.

[Weichel et al. ()] 'Chorioretinectomy for perforating or severe intraocular foreign body injuries'. E D Weichel , K S Bower , M H Colyer . *Graefes Arch Clin Exp Ophthalmol* 2010. 248 (3) p. .

[Coskunseven et al. ()] 'Combined Intacs and posterior chamber toric implantable Collamer lens implantation for keratoconic patients with extreme myopia'. E Coskunseven , M Onder , G D Kymionis , V F Diakonis , E Arslan , N Tsiklis . *Am J Ophthalmol* 2007. 144 (3) p. . (Ref list)

[Fox and Katz ()] 'Developmental lead exposure selectively alters the scotopic ERG component of dark and light adaptation and increases rod calcium content'. W A Fox , L M Katz . www.ncbi.nlm.nih.gov/pubmed/1574840 *Vision Res* 1992. 32 (3) p. .

[Neal et al. ()] 'Effects of Nacetylcysteine and 2,3-dimercaptosuccinic acid on lead induced oxidative stress in rat lenses'. R Neal , K Cooper , H Gurer , N Ercal . http://web.mst.edu/~nercal/documents/publications/30.pdf *Toxicology* 1998. 130 p. .

[Hollier et al. ()] 'Facial gunshot wounds: a 4-year experience'. L Hollier , E P Grantcharova , M Kattash . *J Oral Maxillofac Surg* 2001. 59 p. . (Ref list)

[Cleary and Ryan ()] 'Histology of wound, vitreous, and retina in experimental posterior penetrating eye injury in the rhesus monkey'. P E Cleary , S J Ryan . *Am J Ophthalmol* 1979. 88 (2) p. . (Ref list)

[Dart et al. ()] 'Lead'. R C Dart , K M Hurlbut , L V Boyer-Hassen . *Dart, RC. Medical Toxicology*, 2004. (3rd ed.)

[Lee et al. ()] 'Low-velocity gunshot wounds to the paranasal sinuses'. D Lee , M Nash , J Turk , G Har-El . *Otolaryngol Head Neck Surg* 1997. 116 p. . (Ref list)

[Woodcock et al. ()] 'Mass and shape as factors in intraocular foreign body injuries'. Mgl Woodcock , Rah Scott , J Huntbach , G R Kirkby . *Ophthalmology* 2006. 113 (12) p. . (Ref list)

[Cleary and Ryan ()] 'Method of production and natural history of experimental posterior penetrating eye injury in the rhesus monkey'. P E Cleary , S J Ryan . *Am J Ophthalmol* 1979. 88 (2) p. . (Ref list)

[Shuttleworth et al. ()] 'Ocular air gun injuries: a one-year surveillance study in the UK and Eire (BOSU)'. G N Shuttleworth , P Galloway , J M Sparrow , C Lane . *Eye (Lond)* 2001-2002. 2009. 23 (6) p. . (Ref list)

[Ramstead et al. ()] 'Ocular injuries associated with Airsoft guns: a case series'. C Ramstead , M Ng , C J Rudnisky . *Can J Ophthalmol* 2008. 43 (5) p. . (Ref list)

[Bowen and Magauran ()] 'Ocular injuries caused by airgun pellets: an analysis of 105 cases'. D I Bowen , D M Magauran . *Br Med J* 1973. 1 (5849) p. . (PMC free article. Pub Med. Ref list)

[Kara et al. ()] 'Penetrated shotgun pellets: a case report'. M I Kara , H B Polat , S Ay . *Eur J Dent* 2008. 2 p. . (PMC free article. PubMed)

[Noye et al. ()] 'Penetrating eye injuries caused by firearms. Apropos of 17 cases'. J F Noye , F Bernhard , J P Berrod , P Lesure . *Bull Soc Ophtalmol Fr* 1989. 89 (4) p. .

[Chen et al. ()] 'Penetrating injuries of the face'. A Y Chen , M G Stewart , G Raup . *Otolaryngol Head Neck Surg* 1996. 115 (5) p. . (Ref list)

[Pulido et al. ()] 'Perforating BB gun injuries of the globe'. J S Pulido , S Gupta , J C Folk , K C Ossoiny . *Ophthalmic Surg Lasers* 1997. 28 (8) p. . (Ref list)

[Colyer et al. ()] 'Perforating globe injuries during operation Iraqi Freedom'. M H Colyer , D W Chun , K S Bower , Jsb Dick , E D Weichel . *Ophthalmology* 2008. 115 (11) p. . (Ref list)

[Finkelstein et al. ()] 'Projectile metallic foreign bodies in the orbit: a retrospective study of epidemiologic factors, management, and outcomes'. M Finkelstein , A Legmann , P A Rubin . *Ophthalmology* 1997. 104 (1) p. . (Ref list)

[Smiddy et al. ()] 'Refractive changes after scleral buckling surgery'. W E Smiddy , D N Loupe , R G Michels , C Enger , B M Glaser . *Arch Ophthalmol* 1989. 107 (10) p. . (Ref list)

[Feng et al. ()] 'Risk factors, anatomical, and visual outcomes of injured eyes with proliferative vitreoretinopathy: eye injury vitrectomy study'. K Feng , Y Hu , C Wang , L Shen , X Pang , Y Jiang . *Retina* 2013. 33 (8) p. .

[Gilfillan ()] *Rome's ruin by lead poison*, S C Gilfillan . 1990. Wenzel Press. (1st ed. Long Beach)

[Bushnell et al. ()] 'Scotopic vision deficits in young monkeys exposed to lead'. P J Bushnell , R E Bowman , J R Allen , R J Marlar . `www.sciencemag.org/cgi/content/abstract/sci;196/4287/333` *Science* 1977. 196 p. .

[Mastrapa et al. ()] 'Survival of bacteria exposed to extreme acceleration: implications for panspermia'. Rme Mastrapa , H Glanzberg , J N Head , H J Melosh , W L Nicholson . *Earth Planet Sci Lett* 2001. 189 (1) p. .

[Michels (1982126p)] *Vitreous Surgery Am Acad Ophthalmol*, R G Michels . 1982126p. (Ref list)