Lead Intraocular Foreign Body Injury Following Ejection

Mansur Ali Khan; Deepak Gaur; Praveen C. Murthy; Ashish Pandey

BACKGROUND: Ejection injuries involving the eyes have become uncommon due to effective protection by helmets and visors. We report a unique case of intraocular lead foreign body injury occurring after ejection from a Hawk aircraft in a pilot who had his helmet and visor on.

CASE REPORT: A 40-yr-old male pilot sustained facial injuries after ejection from a Hawk aircraft. He had multiple foreign bodies embedded in the skin around his jaw, corneal foreign bodies, and self-sealed corneal and lens entry in left eye, with one foreign body lodged within the lens and two in the vitreous behind the lens. The foreign bodies showed low reflectivity on CT scan suggestive of plastic. However, spectroscopic and electron microscopic analysis of pieces removed from the cornea confirmed the material to be predominantly lead, which came from the miniature detonator cord (MDC). An electroretinogram (ERG) showed reduction of scotopic b wave amplitude in the affected eye. The pilot underwent intravitreal foreign body removal successfully through pars plana vitrectomy. Post-removal vision recovered from 20/60 to 20/20 with ERG also showing recovery of scotopic b wave amplitude from 100 μV to 180 μV.

DISCUSSION: Though systemic toxicity due to high blood levels of lead are well known, this case is unique in demonstrating direct retinal toxicity because of intravitreal lead foreign body. It also raises aeromedical concerns about the hazards of MDC splatter despite full protection with helmet and visor.

KEYWORDS: aircraft ejection, intraocular, foreign body, lead.

Khan MA, Gaur D, Murthy PC, Pandey A. *Lead intraocular foreign body injury following ejection*. Aerosp Med Hum Perform. 2020; 91(8):674–678.

Modern ejection seats have vastly improved the survivability of the pilot following aircraft ejection, but the pilot may still sustain several types of injuries during ejection either due to the emergency which resulted in ejection (collision, fire, etc.) or due to various forces during the sequence of ejection such as canopy jettisoning, firing of the ejection gun, wind blast, parachute opening, and landing injuries.[7] Rib cage, lung injuries, spinal injuries, and limb injuries are the most commonly reported ejection injuries in ejection survivors, whereas ocular injuries are rare due to modern protective helmets and visors.[11] We report an unusual case of intralenticular and intravitreal lead foreign body from miniature detonator cord (MDC) splatter in a pilot ejecting from a Hawk trainer jet who reportedly had his visor down.

CASE REPORT

A 40-yr-old male pilot ejected from a twin seater Hawk trainer jet following an air emergency. His copilot sitting behind initiated the ejection sequence at his command and the pilots ejected out in sequence, the copilot first, and both landed at a safe distance from the wreckage. They were stabilized on site by the emergency team and transported by road to the nearest military hospital located 40 km away. At the hospital emergency room, the injuries were assessed by a team of trauma care specialists from various disciplines. The lead pilot, who ejected second, did not have any skeletal or internal injuries. However, he had multiple foreign bodes embedded in the skin along the jaws and both lids. The foreign bodies were more numerous on the left side of the face as compared to the right side. Multiple foreign bodies were also seen on the cornea and conjunctiva which were numerous in the left eye and few in the right eye. An urgent whole-body computerized tomography (CT) scan showed multiple corneal foreign bodies in his left cornea, one intralenticular foreign body in the left lens, and two intravitreal foreign bodies in the left eye, whereas the right eye did not have

From the Command Hospital, Air Force Bangalore, India; and IISC, Bangalore, India.

This manuscript was received for review in November 2019. It was accepted for publication in May 2020.

Address correspondence to: Mansur Ali Khan, M.S., FICO, Department of Opthalmology, Command Hospital Air Force Bangalore, Post Agram, HAL Airport Rd, Bangalore, Karnataka 560007, India; mansurophthal@gmail.com.

any intraocular foreign bodies. Both globes were intact without any evidence of penetration or perforation on CT. The reflectivity of the foreign bodies on CT was 275 Hounsfield units, which was suggestive of glass or plastic. No skeletal or visceral injuries were seen on CT scan. Subsequent detailed ophthalmic examination with a slit lamp revealed a hazy cornea in the left eye with a peppered appearance due to multiple impacted greyish-white foreign bodies. There was a self-sealed corneal entry wound and an iris entry wound in the same trajectory with an embedded greyish-white intralenticular foreign body inside the lens in the inferotemporal quadrant just in front of the posterior capsule. The lens was clear, but it had a self-sealed pigmented entry wound and a self-sealed exit wound. The perilimbal conjunctiva also showed multiple embedded foreign bodies. The posterior segment was evaluated after full pupillary dilatation, including examination of the periphery with indirect ophthalmoscopy. The intravitreal foreign bodies seen in the CT scan could not be visualized at this juncture due to the corneal haze. However, there was no evidence of any other posterior segment trauma. The retina was attached and the optic disc, macula, and background retina were normal. The right eye also showed few perilimbal conjunctival foreign bodies and two superficial corneal foreign bodies. There were no intraocular foreign bodies in the right eye and posterior segment was normal. Vision as recorded by the Snellen visual acuity chart was 20/20 and 20/60 in the right and left eye, respectively. Initially the patient was managed conservatively with topical steroid, antibiotics, and cycloplegic drops along with systemic antibiotic prophylaxis. Removal of the intraocular foreign bodies was deferred considering the probable non-metallic characteristic reported on CT, lack of any evidence of infection, and corneal haze with poor visibility, precluding safe surgery. The patient was, however, monitored daily and during this period multiple corneal foreign bodies were removed in several sittings with the slit lamp with the specific aim of clearing the central visual axis and reducing irritation and pain. The corneal haze cleared up 1 wk following injury with vision in the affected eye recovering to 20/30. The intravitreal foreign bodies could now be clearly visualized by the indirect ophthalmoscope in the inferotemporal periphery just behind the crystalline lens. At this stage we were faced with a dilemma whether to proceed to removal of the intraocular foreign bodies or continue with conservative management and observation. Though the general dictum for intraocular foreign bodies is removal, in this case, considering the good visual recovery, lack of any evidence of infection, probable inert nature as reported on CT scan, and structurally normal globe with clear lens, there appeared to be a strong case for conservative management. Considering the high visual standards required for this fighter pilot to continue his career, it was imperative that surgery for removal should not compromise his vision. At this stage a second opinion was sought from a leading expert in the vitreoretinal field and it was decided to send the removed corneal foreign bodies for material analysis at an institute for material sciences. The material analysis of the corneal foreign bodies was reported as having high lead content based on electron microscopy and spectroscopic analysis (**Fig. 1**).

An electroretinogram (ERG) of the eyes was also done which showed significantly diminished scotopic b wave amplitude to 100 μV (lab normal: 180 μV to 300 μV), mildly diminished photopic response in the left eye, and normal responses in right eye (**Fig. 2**). The presence of any subclinical retinal dystrophy which could cause similar ERG abnormality was ruled out with optical coherence tomography (OCT) and fundus autofluorescence of the eyes, which revealed a normal study. In the absence of any other abnormality, the reduction in ERG in the affected eye only was highly suggestive of retinal toxicity due to the intravitreal foreign body.

To identify the source of the foreign bodies, samples from the aircraft canopy and MDC were also analyzed, which revealed polymethyl methacrylate (acrylic) content in the canopy and lead in the MDC sheath, confirming MDC as the source of the foreign body. The lead content and documented

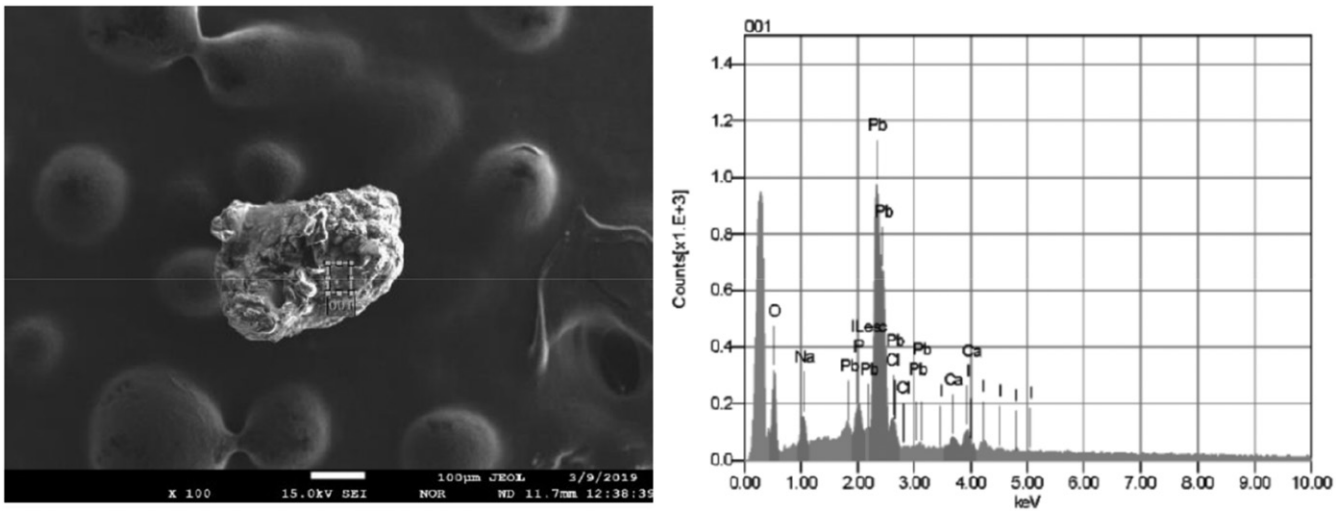

Fig. 1. Material analysis of the foreign body fragments. Scanning electron microscopy and energy dispersive spectroscopic analysis of the foreign body fragment from the corneal surface. On the left is the fragment as seen on electron microscopic imaging and on the right is the graph from spectroscopic analysis showing spikes representing lead.

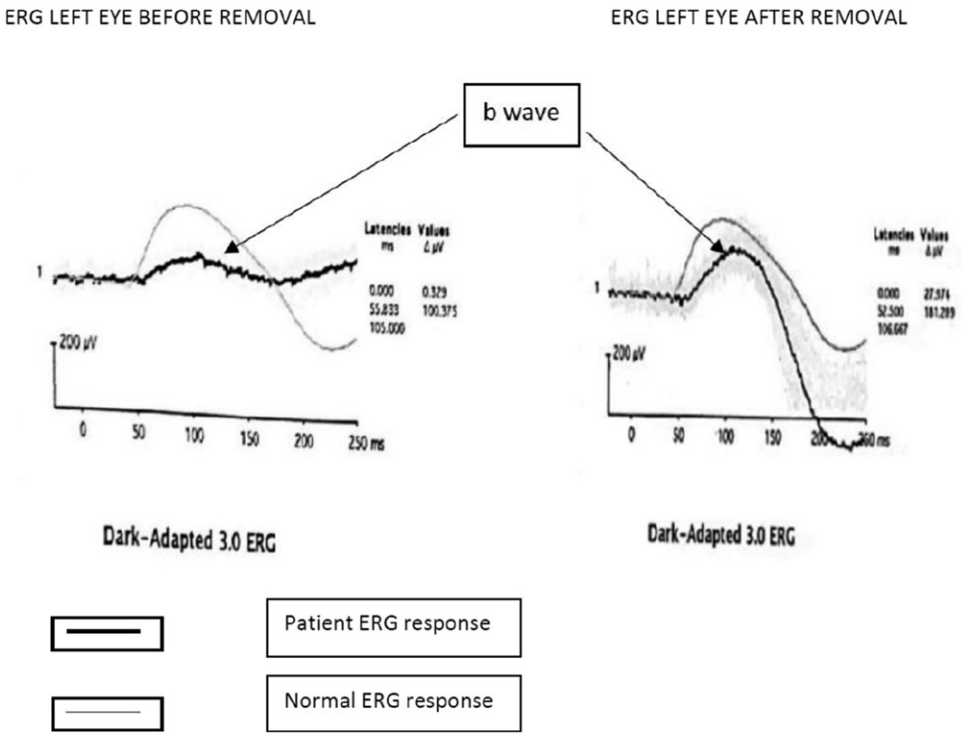

Fig. 2. Scotopic electroretinogram (ERG) of the left eye. On the left the scotopic ERG before removal of the foreign body shows reduction of b wave amplitude to 100 µV (lab normal 180–300 µV). On the right the ERG of the same eye repeated at 4 wk following removal showing recovery of ERG to within normal range (181 µV).

reduced ERG left no doubt regarding the need for removal. An ultrasound B scan for accurate localization and measurement of size was done which showed the two intravitreal foreign bodies and one in the lens to be approximately 1 mm, 0.8 mm, and 1.5 mm, in the largest diameter, respectively (**Fig. 3**).

The need for removal and surgical plan was discussed with the patient and written informed consent for surgery taken. We planned to leave behind the lenticular foreign body as it was sequestered inside the lens with an intact capsule and the lens itself was clear. The patient underwent a 4 port pars plana vitrectomy with a superonasal 23-gauge port and another 3 port of 25 gauge. A chandelier light was introduced through the 6 o'clock port. Following that, the 23-gauge canula at the superonasal port was withdrawn and a 20-gauge gripping forceps was introduced through the scleral opening. The foreign bodies were then removed bimanually with the help of a cutter and forceps under chandelier illumination. The peripheral retina was inspected for any breaks and ports closed. Post-operatively the lens remained clear. Post-operative check ultrasound of the eye confirmed removal of the intravitreal foreign bodies with only one residual foreign body remaining sequestered within the lens (**Fig. 4**).

At 6-wk follow-up, the patient had recovered 20/20 vision in the operated eye with ERG returning to a normal value of 181 µV. The copilot sustained a fractured femur during landing which was successfully operated on. Examination of his eyes at day 1 following injury revealed two embedded foreign bodies in the right lower lid. There was no ocular injury or foreign body in the eyes.

DISCUSSION

Intraocular foreign body injury among aviators dates back to World War II when the inert nature of a canopy fragment lodged in an aviator's eye was noticed by Sir Harold Ridley, inspiring him to invent the intraocular lens.[1] Such injuries have become rare in survivors of modern aircraft ejections due to the use of well-fitted visors which are able to provide effective protection from splinters and fragments. Spinal and limb trauma are the commonest injuries reported in survivors of modern air craft ejections.[4,8] The authors are unaware of any other reports of aircraft ejection related intraocular foreign body injuries in recent literature The Ernsting's text book of aviation and space medicine, in its chapter on escape from aircraft, has highlighted the risk of MDC splatter causing injury to the face and eyes.[5] It is also mentioned that this could occur even with the visor down. However, the exact mechanism of injury through a closed visor is not described. Both pilots in our case reported having had their

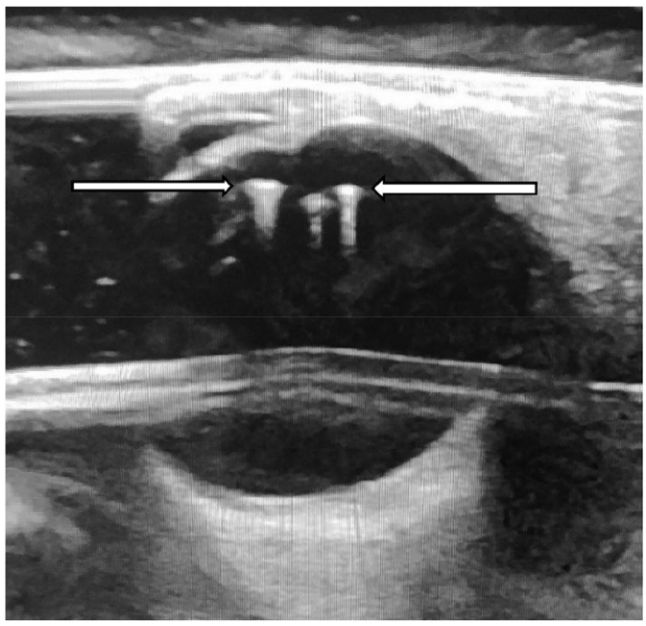

Fig. 3. Ultrasonography of the left eye showing high reflective echoes of the three intraocular foreign bodies. The largest one on the left is in the lens and the two smaller echoes on the right are the intravitreal foreign bodies lodged behind the lens in the vitreous.

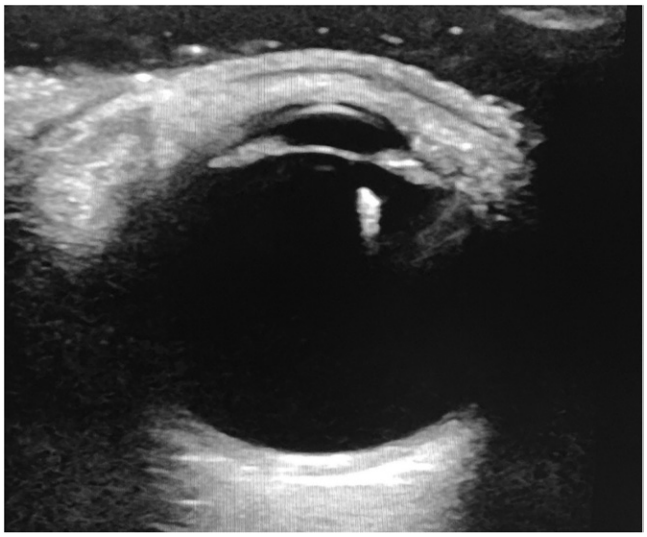

Fig. 4. Post-removal ultrasonography of the left eye showing only the echo of the foreign body left behind in the lens and no intravitreal foreign bodies.

helmets on with visors down during ejection. The headgear and visors of both pilots were found intact by the investigating team. It is hypothesized that acceleration of the seat and wind blast could create a sufficient gap between face and visor to allow the tiny fragments of MDC splatter to get in at high speed. The chief pilot who was the second in the sequence of ejection bore the brunt of the MDC splatter while the copilot had only a few pieces embedded in the lower lid. The time lag between MDC detonation and the sequence of ejection might have been responsible for the pilot ejecting second receiving maximum splatter.

Lead is not a commonly reported foreign body in the eye. The commonest source of ocular injuries due to lead are from air guns and rifles. In a 10-yr survey of ocular trauma by air gun pellets, Shariff et al.[9] did not report any lead poisoning. Kruse et al.[3] reported a case of intralenticular lead foreign body due to a fragment from an air gun pellet which remained lodged inside the lens without any toxicity until it was removed during cataract surgery after 20 yr. In our case the intralenticular lead foreign body has been left inside as the lens is clear and potential for toxicity inside the lens is low, as reported before. Most lead-containing projectiles such as those in bullets cause severe damage to the eye, resulting in severe vision loss from the trauma itself. Our case was unique as the foreign bodies were small and penetrated without causing significant trauma to the eye. This was probably due the small size, high temperature, and speed reached due to detonation and the sharp edges, which allowed easy penetration.

Elemental lead inside the body is known to cause toxicity by inhibition of heme synthesis enzymes as well as thiol containing antioxidants and enzymes.[6] This results in increase in reactive oxygen species, causing oxidative stress. Retinal toxicity due to lead has been reported by Gilhotra et al. as a part of systemic lead toxicity manifesting 13 yr after an episode of acute lead poisoning with loss of vision and reduced ERG in the affected eye.[2] To the best of our knowledge there are no cases reported of intravitreal lead foreign body causing retinal toxicity. This case is, therefore, unique in documenting diminished scotopic ERG due to intravitreal lead foreign bodies which recovered after their removal. Systemic lead poisoning is a chronic condition which occurs after prolonged exposure, whereas in our case the toxicity was seen within 2 to 3 wk of exposure. This indicates that lead can cause acute retinal toxicity if it is in close proximity to the retina such as inside the vitreous. The general dictum for intraocular foreign bodies is to remove them as soon as possible. However, if the risk of infection is low, then deferred removal could be a safe and viable option in cases where the lack of corneal clarity makes the surgery hazardous. This was shown in a large case series from the Iraq war[10] where an average time from injury to removal of 20 d did not affect the outcome or increase incidence of endophthalmitis. In our case we initially deferred the removal of the intravitreal foreign body due to the significant corneal haze. The material analysis which confirmed the lead content in the foreign body and the abnormal ERG were key factors in the decision to surgically remove the foreign bodies from this aviator's eye, which had otherwise recovered good vision on conservative management alone. This case illustrates how a coordinated team effort and an evidence-based clinical decision can result in a satisfactory outcome.

To conclude, this is a rare case report of MDC splatter related intraocular lead foreign body injury in a pilot ejecting from an aircraft. This case showed that intravitreal lead can cause acute but reversible retinal toxicity. The case also underscores the potential hazards of MDC splatter during ejection and the need to evaluate the current helmet and visor systems for their efficacy in preventing such injuries in the future.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Mahesh P. Shanmugam, Head of Retina Services at Sankara Eye Hospital Marthahalli, Bangalore, for his guidance in managing this case. He has provided his professional opinion, which helped us manage the patient successfully.

This case was presented at the 67th International Congress of Aviation and Space Medicine held at Debrecen Hungary from 8 to 12 August 2019.

Financial Disclosure Statement: The authors have no competing interests to declare.

Authors and affiliations: Mansur Ali Khan, M.S., FICO, Professor and Head, and Ashish Pandey, M.B.B.S., Junior Resident, Department of Ophthalmology, and Deepak Gaur, M.Sc., M.D., Principal and Commandant, Command Hospital, Air Force Bangalore, India; and Praveen C. Murthy, M.Sc., Ph.D., Associate Professor, Department of Materials Engineering, IISC, Bangalore, India.

REFERENCES

1. Apple DJ, Sims J. Harold Ridley and the invention of the intraocular lens. Surv Ophthalmol. 1996; 40(4):279–292.
2. Gilhotra JS, Von Lany H, Sharp DM. Retinal lead toxicity. Indian J Ophthalmol. 2007; 55(2):152–154.

3. Kruse FE, Rohrschneider K, Pfau B, Müller WF, Völcker HE. [Prognosis of intralenticular lead foreign bodies.] Klin Monbl Augenheilkd. 1993; 203(2):121–127.
4. Lewis ME. Survivability and injuries from use of rocket-assisted ejection seats: analysis of 232 cases. Aviat Space Environ Med. 2006; 77(9):936–943.
5. Lewis ME. Ernsting's aviation and space medicine, 5th ed. Chapter10, Restraint systems and escape from aircraft. London: CRC Press; 2016:179.
6. Mitra P, Sharma S, Purohit P, Sharma P. Clinical and molecular aspects of lead toxicity: an update. Crit Rev Clin Lab Sci. 2017; 54(7–8): 506–528.
7. Moreno Vazquez JM, Durán Tejeda MR, García Alcón JL. Report of ejections in the Spanish Air Force, 1979-1995: an epidemiological and comparative study. Aviat Space Environ Med. 1999; 70(7):686–691.
8. Read CA, Pillay J. Injuries sustained by aircrew on ejecting from their aircraft. J Accid Emerg Med. 2000; 17(5):371–373.
9. Sharif KW, McGhee CN, Tomlinson RC. Ocular trauma caused by airgun pellets: a ten year survey. Eye (Lond). 1990; 4(Pt. 6):855–860.
10. Thach AB, Ward TP, Dick JSB. 2nd, Bauman WC, Madigan WP Jr, et al. Intraocular Foreign body during operation Iraqi Freedom. Ophthalmology. 2005; 112(10):1829–1833.
11. Visuri T, Aho J. Injuries associated with the use of ejection seats in Finnish pilots. Aviat Space Environ Med. 1992; 63(8):727–730.