Case Report

Bilateral maculopathy following visor up ejection- A case study

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Presented here is a case, of a pilot who ejected from MIG-27 ML a tactical strike fighter aircraft fitted with KM-IM series 2 ejection seat(ES). Ejection occurred immediately following a bird hit on approach. Subsequently, the eject pilot developed persistent visual defects as a result of maculopathy in both eyes. The case is discussed keeping in view the ejection dynamics of ES in ambient environment and its cause and effect relationship towards ophthalmic injuries, course of natural recovery, conventional conservative treatment, current concepts, role of hyperbaric medicine and aeromedical disposition of the pilot. The importance of using visor in all phases of fighter flying is reiterated.

Key Words : Ejection, Maculopathy.

Abandoning a sick aircraft in dire emergency is not always an incidence free affair. An apparently safe landing by an ejection may only give a false impression of safety. Careful observations may reveal presence of indirect, internal or delayed onset type of injury. Open ejections have commonly been associated with surface injuries of the eye, but occurrence of internal injury is rather uncommon. Perhaps, one of the earliest recorded internal ophthalmic injuries from a high performance aircraft [HPA] in IAF was in early 1974, following induction of open ejection variant in the same year [1].

Case Report I

A 27 year old, 177 cm tall male pilot weighing 74 kgs was authorised to carry out a handling sortie on MIG 27 ML. The sortie was uneventful till he was asked to execute an overshoot, in view of a formation of two aircrafts which had lined up for take off. While turning on to downwind he experienced a bird hit on his port air intake. Soon after he noticed warning lights of DC generator come on along with other assorted indications of engine overheat and flame out. By this stage, the height and speed combination of 800 mts AGL and 500 kmph precluded any attempt to relight and the pilot abandoned the aircraft in a planned manner. The pilot was rescued by villagers and the local police. Subsequent medical examination in a service hospital revealed the occurrence of (a) Bilateral ecchymosis and subconjunctival haemorrhages over exposed areas of both eyes Fig -1 (b) Orbital oedema right eye (c) Macular oedema in right eye (d) Bruises on both shins and on the right shoulder with its anterior

dislocation (c) Contusion back.

The X rays of the skull and spine taken following ejection revealed absence of bony injury. He was given conservative treatment and the subconjunctival haemorrhages resolved spontaneously by third week, (fig-2) However the macular oedema continued to persist in both eyes. By the end of sixth week, it resolved with faint glial scarring at macula. The pilot complained of visual difficulties from third day onwards during hospitalisation viz. unclear visual perception of human faces at close quarters, which continued to manifest as difficulty in driving and reading even after discharge from the hospital. Neuropsychiatric examination ruled out the existence of post traumatic stress disorder. Review ophthalmological exam revealed normal acuity of vision. However, funduscopy revealed a pale ring of hypopigmentation with central and peripheral zones of hyperpigmentation (Bull's eye appearance) of approximately 1/4 disc diameter over right macula. Left macula revealed a poorly defined zone of hypopigmentation with stippling of pigment in macular region of approx. 1 and 1/2 disc diameter. Fluorescein angiography done after two months of onset did not reveal any abnormal leakage, poking, zone of ischaemia or hypofluorescence pooling at maculae, barring some evidences of haemorrhages in nasal retina of Rt eye corresponding to blocked fluorescein. (Fig - 3.)

Amsler chart showed an area of scotoma around the point of fixation (Fig-4) . Bjerrum screening revealed zone of scotoma more extensive in Lt than the Rt eye, restricted to 10° of visual field around point of fixation (fig-5). Nine months later ophthalmological examination was normal except that the macular areas showed dull foveal reflex with pigmentary stippling in either eye. Field charting revealed absolute scotomas with steep margins within 5° of fields around point of fixation. In addition, the right eye showed scotomas scattered between 150°–200° along 135-150 and 210-260 meridians above and below the right blind spot. In left eye, absolute and steep scotoma extended between 15-20° along 25-65 meridian. The pilot was found healthy otherwise with no physical, cardiovascular, metabolic and other disorders which could have potentially contributed towards impaired visual functions.

Discussion

Cause of Injury : The pilot, after overshooting was in the process of turning on to down wind when he sighted a flock of birds in his flight path from his left side. Before he could react and initiate an avoiding action, the aircraft had sustained a massive bird hit leading to the engine flame out. At that moment the aircraft was flying at about 1050 mtrs AGL at IAS of approximately 564 kmph in an attitude of shallow climb of 7° nose up with 35° roll to the right. It could mean that just before the ejection the pilot was under the influence of minimal +Gy acceleration with eyes looking towards right and downwards. From the point of human tolerance, the ejection was initiated below 1/3 of the max speed of the aircraft viz 1700 kmph or 1056 mph [1.6 mach] at the lowest fringes of medium level altitude. Hence the ejection was well within the safety envelope and the capabilities of KM-IM [ES] provided the protective flying clothing and equipment including crash

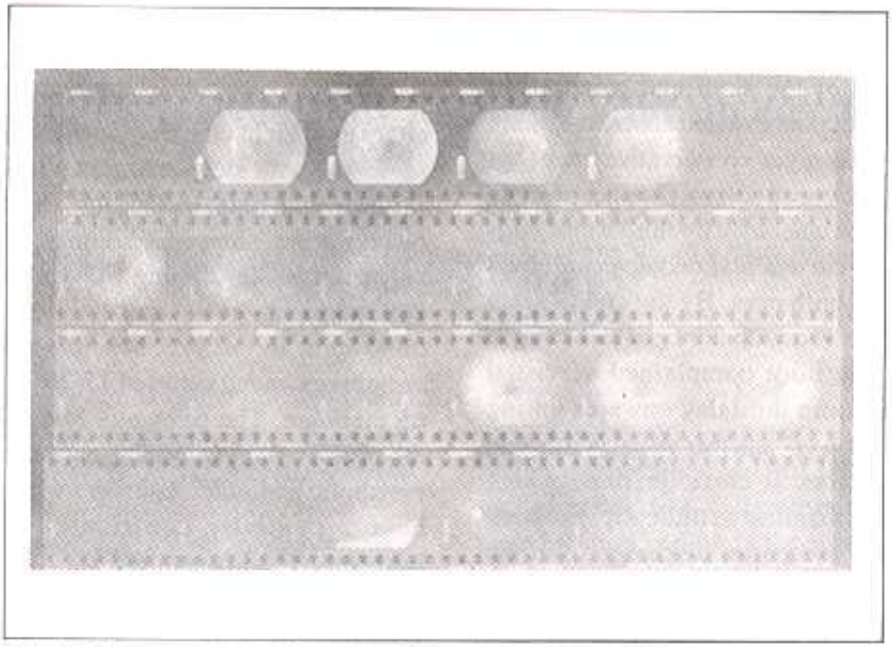

Fig 1 - Flourescein Angiography following 2 months of incidence, showing evidence of haemorrhages in nasal retina of right eye, corresponding to blocked flourescein.

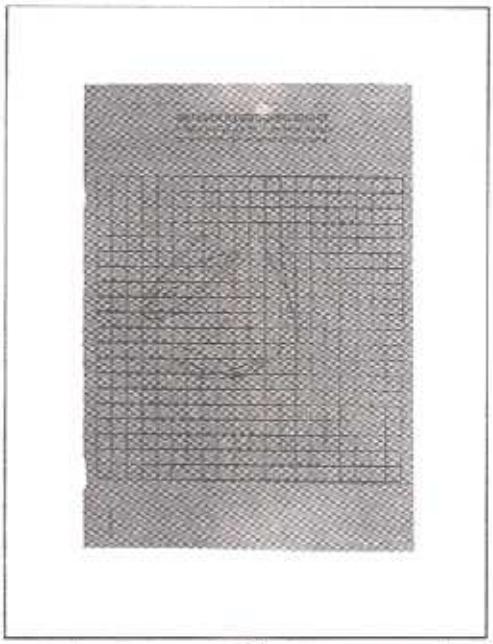

Fig-2 Amster chart showing area of Scotoma around point of fixation.

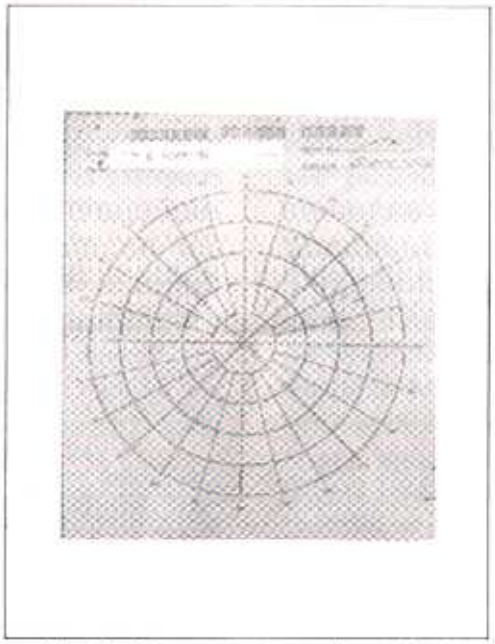

Fig-3 - Bjerrum screen chart - Lt eye

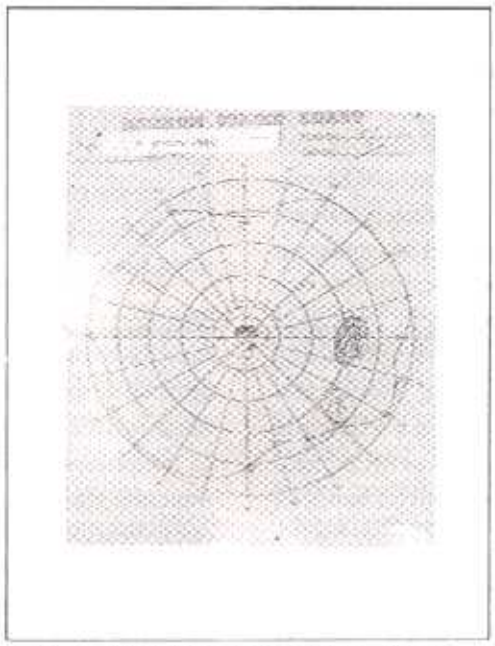

Fig-4 - Bjerrum screen chart - Rt eye

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helmet ZSH - 3M with its visor, KM-32 oxygen mask worn by the pilot were properly used in their appropriate positions. During the court of inquiry [1] it was found out that though the flying clothing was recovered intact the visor was not lowered for want of increased visibility as neutral grey visor is felt to impair it considerably. The visor failed to come down spontaneously despite rapid built up of 'Gz during assisted egress by KCM combined ejection gun system. No specific reason was found, however it was probably due to mechanical failure coupled with altered position of the head.

It is obvious that the pilot was exposed to severe wind blast on his eyes unprotected while he ejected at speed of 528 kmph (293 kts) well within the recommended ejection speeds of the order of (250-300 kts) 450-540 kmph. At these levels the forces are known to cause loss of spectacles, head gear etc. in some crew [6]. Wind blast injury is supported by the fact that subconjunctival haemorrhages were essentially within the exposed palpebral fissures of both sides with the exception of nasal conjunctiva of Lt eye. (Fig-2.) Ecchymoses and orbital oedema are indicative of impingement of excessive blast forces. The ophthalmic injuries are unlikely to occur in subsequent phases of ejection in absence of evidence of fouling, excessive parachute opening shock, and tolerably transmitted forces on heels while landing on soft even surface and subsequently diffusing them out on buttocks and right shoulder.

Low use of visors during flying is not uncommon amongst fighter pilots. Many of the pilots on Russian aircrafts do not use neutral grey tinted visor mounted on GSH-3M helmets under compromised visibility conditions especially during approach and landing and flying over certain terrains due to its merging effect on ground features as compared to blue green visors [9]. On the other hand O' Connell et al [6] have found low use of clear visors on modern US fighters as well, on account of discomfort due to reflections and duplication of light sources both within and outside the cockpit and difficult exchange with daytime tinted visor. The safety concern regarding non lowering of visor still remains a debatable issue amongst fighter pilots viz. better vision vis-a-vis rare risk of injury. More so, as minor abrasions and lacerations have been recorded over exposed parts of the face in 20-25% of ejected pilots even in visor down ejections [6]. On a similar type of Russian aircraft at the same base, another pilot could withstand blast forces well in visor down condition following a total failure of canopy at an altitude of 4.7 kms with speed of 800 kmph. Following the emergency, he cruised for 17 min at a lower height of 1 km at reduced speed of 350 kmph. He sustained only an uncomfortable roughness over the exposed skin of his face, which resolved spontaneously within a few days [9].

Ocular tolerance to wind blast is a multifactorial attribute. Gaverau [4] found epithelial damage to cornea due to wind blast in free fall parachutists, manifesting as temporarily decreased visual acuity and punctate staining. On the other hand some open ejections at high speeds with total loss of head gear have not resulted in similar or other ocular injuries. Nevertheless, the risk of ocular injuries is dependent on indicated air speed, air flow pattern, openness of eyes,

protection provided by oxygen mask assembly, position and usage of visor, face blind and rotation of head gear during early phases of ejection. Topical dynamic pressures may further be altered by position and direction of face besides other factors. Continued attempt to locate the bird with bare eyes could have enhanced the effects of wind blast in this particular case.

Post Ejection Maculopathy : Spontaneous occurrence of scotomas is rare in the young. Under routine clinical conditions it is primarily a disease of the elderly, associated with hypertension, hyperlipidemia, coronary artery disease, tobacco use, central and branch retinal vein occlusion and presence of positive anti nuclear antibodies. The pilot had maintained good binocular vision since his entry into IAF in 1983. The haziness in vision appearing after two days of hospitalisation has some similarity with the ophthalmic findings observed during first visor up ejection on high performance fighter in 1974, in which the pilot started complaining of haziness of vision in Rt. eye from third day of his ejection. In both these cases, gross near and distant vision remained unaffected right from the first day of ejection, which could be explained by intact foveal functions and distribution of scotomas paracentrally. Macular oedema (ME) in the former was characterised by fogging of letters and words, absence of foveal reflex and dull macula. Full recovery occurred during the first week of ejection with conventional treatment on Prednisolone, Nicotinic acid and modified rest. In this particular case ME persisted for over a month and resolved only with scarring at macula despite similar conservative treatment as an in patient.

The appearance of fogginess and macular oedema within two to three days of ejection is indicative of reactive nature of its pathogenesis in contrast to subconjunctival haemorrhages and ecchymosis which occurred immediately on direct exposure to wind blast. The retina could in turn be injured by sudden compression of media and neurovascular elements. Retinal oedema usually results from plasma leakage from its damaged blood vessels. A less extensive short term ME is usually reversible. In severe and prolonged ME, the chronic plasma extravasation continues forming hard yellow exudates of serum histiocytes, macrophages and cell debris [2,7]. The degenerative process may cause formation of microcysts which tend to coalesce into larger cysts. Lamilar cysts formed at the fovea lead to a permanent loss in central vision [8]. The contribution of acute hypoxia resulting from short term hydrostatic displacement of blood under high positive +Gz force during egress alone is unlikely to cause ME. The eye has adequate Oxygen reserve akin to other brain tissue, and this can last longer than 1.4 seconds (time of egress). The deccelerating forces did not reach beyond threshold during any stage of escape in any of the axes.

Management Strategies : Irrespective of mechanism of injury, the pathogenesis of ME involves sufficiently prolonged hypoxia or ischaemia and secondary oedema to traumatised, obstructed [7] or sensitised blood vessels. In a healthy young aviator where other disease and age related confounding factors are already excluded, the accepted treatment of ME remains rest, analgesics and corticosteroids along with other symptomatic relief. Considering the

potential long term effects of rapidly occurring gravito inertial forces resulting in prolonged localised hypoxia through coup or contracoup vascular damage within the orbit, neurocompression or pull on nervous elements, hyperbaric oxygenation [HBOT] is considered promising. The ocular effects of HBOT are veasoconstrictive which help in reduction of blood flow and oedema, at the same time providing high oxygen concentrations in dissolved form to media and retinal elements due to its increased diffusion distance irrespective of disruption of vascular elements. These effects are similar to those observed in reduction of cerebral oedema following hyperbaric oxygen treatment. During exposure to HBOT between 2.2-2.8 ATA, the partial pressure of oxygen is built upto 1500-2000mmHg in lungs with dissolved oxygen of 4.6 ml% against a little over 100 mmHg in lungs with dissolved oxygen of only 0.32 ml% in blood while breathing air at sea level pressure. The administration of clinical oxygen even by enhancing inspired oxygen fraction FIO_2 to 100%, is able to provide oxygen only upto one third of resting tissue demands in healthy individuals, as the solubility of the blood is low under sea level conditions. Various studies have confirmed improvements in cases of various maculopathies including those resulting from cystoid macular oedema with hyperbaric oxygen treatment [5,7,] while it was not proven effective wherein the underlying pathology was occlusive in nature [3]. However in this particular case, HBOT was not tried. Flourescein angiography had substantiated some disruption of vascular elements as evidenced by residual haemorrhages and thereby inevitable retinal hypoxia.

Aeromedical Disposal

After one and half months of hospitalisation the pilot was awarded 6 weeks of sick leave for convalescence in Med cat AtGt. Following his readmission at the end of three months of onset, he was awarded A4G3 [T-24] for post-ejection maculopathy and anterior dislocation of Rt shoulder. On subsequent review at AFCME, he was recommended to continue in Med Cat A4G3 (T-24) for maculopathy with restricted ground duties not involving unusual stress and advised to observe caution while driving. In order to enhance the objectivity and accuracy in aeromedical disposal, he was advised to present himself with automated perimetry on his subsequent review. Meanwhile the pilot was awarded non flying category with A4 (P) and G3 (T) classification. Subsequently, the pilot lost his flying status permanently due to irreversible macular involvement and significantly large scotomas incompatible with any flying duties. Off-central compensation of vision by peripheral retina in the event of bilateral involvement of eyes is unreliable and potentially hazardous to flight safety.

Conclusion

The occurrence of delayed onset macular oedema should be anticipated in all high speed visor up ejections. The likely appearance of symptoms and signs could be between two to three days during post ejection period and should be monitored carefully. In view of the unacceptable sequel of neurovascular damage to retina under rapid onset gravito-inertial and environmental forces during ejection, early administration of hyperbaric oxygen therapy

is prudent as an adjunct to conventional treatment in order to enhance reduction in macular oedema and improve topical oxygenation, Further studies on effects of HBOT on post ejection maculopathies are recommended.

References

1. Court of Inquiry : Flying accident MIG-27 ML, TS 528 Oct 05 at 28 Wing AF.

2. Duke Elder S, Dobre JH: System of ophthalmology. In disease of the retina. Vol 10 St Louis MO:CV Mosby 1967 :98-120

3. Flynn WJ, Greeen RP Jr, Lo Russo FJ : Retinal vein occlusion. Case reviews of USAF aviators : Aviat Space Environ Med 1974:65:332-7.

4. Gavreau HK : Effects of wearing the Bausch and Lomb 'Softlens while sky diving. American J Optom. Physiol. Opt. 1976:53:236-42.

5. Morse PH : Practical management of Diabetic Retinopathy Norwalk CT : Appleton century crofts 1985:25-51.

6. O'Connell SR, Markovits AS : The fate of eye wear in aircraft ejections. Aviat Space Environ Med 1995:66-104-7.

7. Progg DS, Thorn SR : Preliminary report on the effect of hyperbaric oxygen on cystoid macular oedema. J Cataract Refrac Surg 1987,13:136-40.

8. Yanoff M, Fine BS, Bruckner AJ, Eagle RC : Pathology of human macular oedema, Surg ophthalmol [Suppl] 1984:L28:505-10.

9. Flight Safety file on ejections : 28 Wing AF and personal communications.

10. Medical History Envelopes and Enclosures Air Crew : Medical Boards, Air HQs and 28 Wg AF.