Through Canopy Ejections: An IAF Experience

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ABSTRACT

Background and Objectives: The purpose of an ejection seat is to assist the pilot in escaping from a disabled aircraft safely. Presently, the seat is designed to get propelled out of the aircraft by an explosive charge or rocket motor, carring the pilot along. Injuries sustained by aircrew during ejection depend on several factors including the ejection time sequence. The present study was undertaken to analyze the injuries associated with through canopy ejections in Indian Air Force from the year 1998 to 2012.

Methodology: Completed forms of 'Medical Report on A Major Aircraft Accident-IAFF (MS) 1956' of all ejections from 1998 to 2012, held at the Department of Human Engineering and Department of Aviation Pathology at Institute of Aerospace Medicine (IAM), IAF were analysed for different ejection injuries with a special consideration to the cases of through canopy ejections.

Results: There were a total of 56 completed of 'Medical Report on A Major Aircraft Accident IAFF (MS) 1956' forms were held from 1998 to 2012. Of the 56 cases, 3 cases of through canopy ejections were analysed and discussed in this paper. In all 03 accidents, aircrew had ejected safely and survived. However, there were multiple injuries sustained by the aircrew which commensurate with the kind of injuries which generally occur during various stages of ejection. The importance of personal aircrew factor like strength of neck muscle mass is brought out in the analysis. Interestingly, the aircrew with lower body weight had sustained more cervical injuries in comparison to the other aircrew with higher body weight.

Conclusion: The use of ejection seats by the aircrew to escape from a disabled aircraft is generally a lifesaving measure. However, it exposes aircrew to some unusual forces, which may be beyond the human tolerance limits. Many factors influence the injury potential during the ejection viz canopy thickness, angle of impact of head with canopy, aircraft altitude & attitude, posture during ejection and aircrew factors like adequate sleep before the sortie, pre-flight meal and strength of neck muscle. The study brought out the role of poorly developed neck muscle mass towards cervical injuries in three cases of through canopy ejection.

Keywords: *Ejection,Pilot, Through canopy ejection injuries.*

INTRODUCTION

Whenever an aircraft gets disabled or the aircraft is beyond the aircrew's control, the only option available with the aircrew is to leave the unsafe confinement of the cockpit. The means for escape must be available at all times and must take into account the forces that may be operating on the aircraft, e.g. aerodynamic, acceleration or rotation. In high speed aircraft, escape is achieved by mechanical ballistic push-out technology provided by automatic ejection seats [1]. During the ejection sequence, human body is subjected to numerous forces. When these forces exceed the human tolerance limits, likelihood of serious injuries increases [2]. Spinal injuries constitute the most common and serious injuries during ejection. The ejection seat is designed to propel the seated occupant out of the aircraft with a force adequate enough to clear the aircraft structures and provide sufficient height to the ejected seat to enable the main parachute to deploy fully [3].

The success of assisted escape depends on the flawless execution of a programmed sequence of events. Once the process is initiated, two distinctly different processes are set into action. First, the clearance of the ejection pathway and second the process of ejection of the seat from the aircraft are the events in sequence [1]. Through-the-canopy ejections are novel and have contradictory requirements since the tough materials which resist bird penetrations also resist "punch through" ejections.

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Alternative methods are to provide emergency ground egress capability if normal canopy opening is not feasible[4]. The degree and severity of vertebral injury occurring due to through canopy ejection is proportional to the velocity of the head when it strikes the canopy. More reliable method for canopy jettisoning or use of encapsulated seats (like the seats used in Soyuz space capsule) will reduce the severity of post-ejection injuries to a greater extent.

MATERIAL AND METHODS

Available completed forms of IAFF (MS) 1956' of all cases of ejections of IAF between 1998 to 2012, held at Department of Human Engineering and Department of Aviation Pathology at Institute of Aerospace Medicine (IAM) were analysed. The overall outlook of IAFF (MS) 1956 is portrayed below:-

(a) **Appendix 'A'** - Aircraft Accident-Equipment and Human Factors.

  (i) Part I- Equipment in Use.

  (ii) Part II- Medical History.

  (iii) Part III- Physiological and Psychological Factors.

(b) **Appendix 'B'** - Aircraft Accident-External Medical Examination.

(c) **Appendix 'C'** - Aircraft Accident-Post-Mortem Report.

(d) **Appendix 'D'** - Report on an unassisted escape from an aircraft inflight.

(e) **Appendix 'E'** - Report on the use of Ejection Seat.

(f) **Appendix 'F'** - Survival from an Aircraft Accident.

  (i) Part I- Water Casualty

  (ii) Part II- Land Casualty

A total of 56 ejection cases were analysed. 9 of these ejections were found to be fatal. The 3 through canopy ejections were non fatal. Through canopy ejection injuries were exclusively studied in this paper focussing on Appendix 'A', 'B' and 'E'. Descriptive statistics was used for data analysis.

RESULTS

The 3 through canopy ejections were non-fatal. However, there were multiple injuries sustained by the aircrew which commensurate with the typical injuries occurring in various stages of ejection which has been discussed later in this paper. The flying experience of these aircrew were in a range of 615 to 1565 hours. All 3 aircraft were in descending attitude when ejection was initiated.

Details of the type of aircraft & ejection systems, flying envelopes, causes of ejection and injuries sustained by all 3 aircrew are depicted in Table 1.

Table 1: Details of the Pilots (n=03) underwent Through Canopy Ejections.

Sl. No.	Age in Years	Aircrew Ht, Wt, BMI	Aircraft Type	Ejection Seat	At the time of Ejection		Cause of Ejection	Injuries Sustained
					Ac Altitude	Ac Speed		
1	23	175 cm 70 Kg 22.8	MiG-21 T-96	KM-1M	6900 ft	650 kmph	Engine flameout	- Neck strain - Laceration over Rt elbow - Concussion head injury

2	32	167 cm 78 Kg 27.9	HJT-16 (Kiran Mk II)	MB-Mk IV	600 ft	230 kmph	Engine failure	Fracture of D 12 vertebra Laceration & Haematoma over Rt arm
3	30	173 cm 63 Kg 21	MiG-21 T-75	KM-1M	5900 ft	450 kmph	Engine flameout	Comminuted fracture of C5 and C6 vertebrae

On consideration of other personal factors related to these mishaps like Pre-flight meal, history of adequate sleep,it is found that all 3 aircrew had pre-flight meals 1-3 hours before the sortie, had more than 8 hours of night's sleep prior to under taking the sortie. It is also pertinent to mention that all 3 aircrew were rescued within 20-80 mins post accident. Furthermore, among these aircrew 2 were found unconscious, 1 was fully mobile during rescue.

DISCUSSION

Though ejection seats were introduced in 1940, it is only the modern ejection seat system, which has increased the post-ejection surrivability substantially. Typical survival rates quoted in the literature vary from 80-97% [5]. A total of 56 completed forms of IAFF (MS) 1956 from 1998-2012 were analysed in this study. Out of these 56 ejections, only 3 were through the canopy. Historically, early ejection systems required manual jettisoning of the canopy before the seat activation. Over a period, systems became more sophisticated, and automatic canopy removal mechanisms were incorporated into the ejection systems [6]. In this study, through canopy ejections were considered those where the canopies were not fragmented fully or failure of the automatic canopy jettisoning/fragmentation system. In this study all 3 ejections were caused by engine failure or flameout. 2 ejections were from KM-1M ejection seat of Soviet origin and 1 is from MB-Mk IV seat of British origin. Injuries during ejection may occur at any stage and are generally peculiar to the stages [7]. Typical ejection injuries are listed in Table 2.

Table 2: Injuries in various stages of Ejection (Lewis 2002).

Sl. No.	Stages of Ejection	Possible Injury
1	Ejection Path	Burns from MDC, rocket motor flash, drogue gun
2	Through Canopy	Perspex injuries, Canopy (Mid-rib), Injuries to cervical spine, shoulder injuries, flailing limb injuries
3	Ejection Gun Firing	Spinal compression fractures, femoral fractures
4	Windblast	Wind blast flail injuries
5	Drogue parachute deployment	Spinal injury from drogue parachute opening shock
6	Main parachute canopy deployment	Spinal injuries from main parachute opening shock loads. Head and cervical spine injuries from helmet and parachute riser interaction
7	Landing injuries	Lower limb fractures, spinal injuries

In this paper, all 3 cases which are discussed, the ejection occurred through the canopy. Various injuries [8] which were documented in through canopy ejections are as follows:-

(a) Modification of the acceleration profile for the seat and of the seat occupant causes greater accelerations at the level of the seat and of the body segments represented by the pelvis thorax and head. This produces greater compression of the vertebrae.

(b) Impact between the canopy and the head, shoulders and knees.

(c) Tearing of the protective clothing, damage to survival equipment andlaceration to underlying tissue may be produced by fragments oftransparency which have pierced variouslayers of clothing evident from the cases.

Injury pattern analysis showed more cervical injuries in younger pilots (Table 1). The elder pilot suffered fracture Thoraco-Lumbar vertebrae rather than injuries to Cervical vertebrae. The elder pilot often comes under overweight category. Both the younger pilots with normal range of BMI mass suffered injuries at the Cervical vertebrae. Also, according to Freeman, lighter and smaller subjects have greater injury risks than regular stature people. That is the reason during car crashes, women are twice as often wounded at the neck than males because of smaller stature [9].The neck injuries might have also been attributed to design and training outcome. In order to reduce ejection injuries, aircrew are taught to brace themselves, to keep the spine erect and the head leaned against the seat's headrest before initiating ejection. Seat stability minimizes torsion and flexion loading of the neck [10].

In a study concluded by Yacavon et al. only 17% of through the canopy ejections were not associated with any kind of injuries, while almost 32% of those who jettisoned the canopy prior to seat-travel, escaped injury-free. This greater injury potential for through the canopy ejections can be attributed to the higher G-loads created by the necessity of deforming and subsequently breaking the canopy. In addition, contusions, lacerations and abrasions were commonly experienced by those who exited breaking the plexiglass [6]. In all the 3 cases, canopy was made up of perspex glass with an average thickness of 8-10mm. Factors which might influence the injury potential are material of the canopy, canopy thickness, angle of impact with the canopy and protective headgear of the aircrew.

Through the canopy ejection systems necessitate that the canopy be fragilized just prior to egress otherwise the pilot could be seriously injured or killed. Thus, a fragilization system must be reliable, safe, lightweight, and cost effective if future fighter aircraft are to realize the benefits of modern technology[11]. The helmet canopy acrylic interaction, helmet weight and with helmet to head coupling, will certainly change head and neck response to even presumably safe exposure levels during canopy penetration [12].

Limitations

Many variable factors were not taken into consideration in this study such as degree of the pitch down of the aircraft, wind blast forces, detailed state of helmets after ejection (data not available) to determine that they absorbed the impact force that transferred to the ejectee.

CONCLUSION

Ejection mechanism in an aircraft is lifesaving. At the same time it is dangerous and can cause grievous injuries including spinal injuries. Chances of injuries are more in through canopy ejections rather than in canopy jettisoned ejections. The new generation seats have reduced chances of spinal injuries by reducing the incident acceleration to the occupant by using programmed rocket motors. Pilots with low neck muscle mass are more prone to cervical injuries comparing to other pilots with more neck muscle mass. Two younger and lean pilots with low neck muscle mass had predominantly more cervical injuries in this study. Although many other factors contribute to the injury, one of the factors may be the age of the pilot which is directly related to the body composition. Through canopy ejections, not only result in more injuries, but more severe injuries.

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Disclaimer

The opinions expressed in this article are those of the authors and do not reflect the official views of the Indian Society of Aerospace Medicine or Indian Air Force.

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