Original Paper

SURVIVABILITY AND EJECTION INJURY PATTERN IN BANGLADESH AIR FORCE FIGHTER AIRCREW: A 30 YEARS STUDY FROM 1982-2012

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Abstract

Introduction: Fighter flying is one of the most hazardous occupations known to man. Emergency escape from the aircraft is an important issue to ensure the safety and survivability of aircrew. In spite of advancement of ejection system, both rate and severity of injuries sustained during ejection remain a cause for concern.

Objectives: The purpose of this study was to assess the number of survivability, causes of death in fatal cases, patterns of ejection injuries among the aircrews of Bangladesh Air Force (BAF) and to find out the ways to minimize the fatality and injuries during escape from disabled aircraft.

Methods: This descriptive case series study was conducted at the BAF flight safety directorate and Combined Military Hospital (CMH), Dhaka among the aircrews of Bangladesh Air Force fighter planes which were crashed during the period of 1982 to 2012. The records of injuries, medical documents during admission at hospital, radiological and laboratory investigations reports, clinical analysis of pilots were utilized for this paper. Post mortem reports of fatal cases were also carefully considered.

Results: Out of 23 ejection cases 10(43.48 %) were fatal and 13(56.52%) cases were non fatal. All the pilots (100%) had multiple abrasions, bruises, lacerations in their body. Penetrating injury was observed in one case (10%), one (10%) body was totally mutilated and 06(60%) showed burn injury. All the pilots had thoracic spine compression fracture (100%), 8(80%) had cervical hangman's fracture and lumbar spine fracture. Seven victims (70%) had ruptured diaphragm, 6(60%) had ruptured liver, 5(50%) had ruptured spleen, 2(20%) pilots had ruptured kidneys and urinary bladder. All the pilots (100%) had fracture of lower limbs, 8(80%) had fractured upper limbs. Among the non fatal cases all the pilots (100%) had multiple abrasions, bruises, 6 (46.15%) had laceration, 01 (7.69%) each sustained anterior cruciate ligament tear of knee joint (Lt) and fracture middle of the shaft of the humerus (Lt). The mean age of the pilots was 31yrs (24 – 41 yrs).

Conclusion: Protective measures and training among aircrews should be updated, so that less injury occurs in survivors. Thorough medical diagnosis and psychological treatment are required for the injured aircrews.

Key-words: Ejection injury, Aircrew survivability, Fighter plane crash.

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Introduction

Injury data for aircrew of a crashed aircraft, like autopsy and toxicological results on those fatally injured, have long been used for identifying safety deficiencies in aircraft design, assessing effectiveness of safety equipment and developing strategies to improve the survival of individuals in aviation crashes. Cullen and Turk[1] postulated that analyses of injuries sustained by occupants are of value in three ways: reconstructing the crash event, evaluating the safety equipment and resolving the multitude of medico legal issues. The development of air crash investigation in commercial airliners had its origin in the mid 1920s, when after the enactment of the Air Commerce Act of 1926 the commerce dept of the United States proceeded to develop safety regulations and earliest approaches to the investigation of accidents. Afterward, the Rockne crash, a commercial aircraft accident in Kansas in 1931, in which eight persons were killed, served as the basis for further accident investigation[2]. The purpose of this study was to assess the number of survivability, causes of death in fatal cases, patterns of ejection injuries among the fighter aircrews of Bangladesh Air Force and to find out ways to minimize the fatality and injuries during escape from disabled aircraft.

Materials and Methods

This descriptive case series study was conducted among the aircrews of Bangladesh Air Force fighter planes which were crashed during the period of 1982 to 2012. The study was conducted at the BAF flight safety directorate and Combined Military Hospital (CMH), Dhaka. We categorized military aircraft accidents into two groups – fatal and non-fatal. All aircrew after a nonfatal accident were hospitalized for a complete evaluation before being returned back to flying duties. The records of injuries, medical documents during admission at hospital, radiological and laboratory investigations reports, clinical analysis of pilots were utilized for this paper. Post mortem reports of fatal cases were also carefully considered. All these data were later on analyzed. From ethical point of view necessary consent have been taken from concerned persons.

Results

During the last 30 years (1982- 2012) a total of 23 ejection cases (Table-I) occurred from different types of military fighter aircraft (Fig-1,2,3,4). Out of these 10(43.48 %) were fatal and 13(56.52%) cases non fatal (Fig-5). Among the fatal cases all the pilots (100%) had multiple abrasions, bruises and lacerations in their body. Head injury was found in all of them (100%) which included fracture of skull bones. Penetrating injury of occipital bone by canopi glass was observed in one case (10%) . Body of one of the pilot was totally mutilated (10%) and 06(60%) showed burn injury. Considering the location of thoracic injury all the pilots had thoracic spine compression fracture (100%), 8(80%) had cervical hangman's fracture, 8(80%) had lumber spine fracture and 4(40%) had pelvic fracture (Table-II). Thoracic injury included ruptured heart in 7(70%) cases and ruptured aorta in 4(40%) cases. Seven victims (70%) had ruptured diaphragm, 6(60%) had ruptured liver, 5(50%) had ruptured spleen, 2(20%) pilots had ruptured kidneys and urinary bladder. All the pilots (100%) had fracture of lower limbs, 8(80%) had fractured upper limbs and 2(20%) showed fractured pelvis. Among the non fatal cases all the pilots (100%) had multiple abrasions and bruises in their body (Table-III). Laceration was found in 6 (46.15%) cases. One case (7.69%) sustained anterior cruciate ligament tear of knee joint (Lt) and 01 case (7.69%) sustained fracture in the middle of the shaft of the humerus (Lt). Incised wounds were found on the side of the neck, face and upper arm of 7(53.84%) pilots. One case (7.69%) had fracture of lower limb- right tibia & fibula, 02(15.38%) had compression fracture of T12, L1 vertebrae and 4(30.76%) had burn injury. The mean age of the pilots was 31yrs (24 – 41 yrs).

Table-I: Aircraft wise Fatal and Non Fatal Ejection Injuries (n=23)

Type of Aircraf	Total No of eject on (n=23)	No of Fatal Injury (n=10)	No of Non Fatal Injury (n=13)
F-6/ FT-6	09	03	06
Nanchang A-5 Combat	04	3	1
F-7 Combat	3	1	2
FT-7	3	0	3
Mikoyan-Gurevich MIG-21 warbird	1	1	0
FT-5	1	1	0
Aero L-39 Albatros	2	1	1

Table-II : Pat ern of Fractures in Fatal & Non fatal Aircraft Accidents

Type of injury	Fatal cases (n=10) No of vict ms	percentage	Non fatal cases (n=13) No of vict ms	percentage
Skull fracture	9	90	-	-
Penetrat ng injury skull by canopy glass	1	10	-	-
Cervical Hangman's fracture	8	80	-	-
Thoracic spine fracture	10	100	2	15.38
Lumber spine fracture	8	80	2	15.38
Pelvic fracture	2	20	-	-
Fracture of upper limbs	8	80	1	7.69
Fracture of lower limbs	10	100	1	7.69

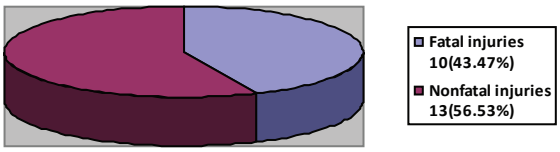

Fig-5: comparison of fatal and non fatal ejection ases.

Table-III : Pat ern of Soft Tissu and Viscera Injury in Fatal & Non Fatal Aircraft Acc dents.

Type of injury	Fatal cases (n=10) No of vict ms	percentage	Non fatal cases (n=13) No of vict ms	percentage
Mult ple abrasions & bruises	10	100	13	100
lacerat on	10	100	6	46.15
Incised wound in face & body	10	100	7	53.84
Rupture of heart	7	70	-	-
Rupture of aorta	4	40	-	-
Rupture of diaphragm	7	70	-	-
Rupture of liver	6	60	-	-
Rupture of spleen	5	50	-	-
Rupture of kidney	2	20	-	-
Rupture of urinary bladder	2	20	-	-
Burn of various degree	6	60	4	30.76
Mut lat on of body	1	10	-	-
Anterior cruciate ligament torn in knee joint	-	-	1	7.69

Fig-1: Nanchang A-5 combat aircraft c ashed at Patenga.

Fig-2: Aero L-39 Albatros combat aircraft c ashed at Tangail.

Fig-3: FT-6 aircraft c ashed at Barisal, both pilots were dead.

Fig-4: Crashed Nanchang PT-6 Trainer aircraft

Discussion

The mechanism and pattern of injuries sustained in aircraft accidents can provide vital information for improving survivability[3]. Moreover, injury patterns could provide insights into medical standards for flying duties. The primary goals of the medical examination are to determine the identification of the casualties, causes and manner of death. The autopsy is a primary tool in developing the information for answering most of the forensic questions and must be supported by extensive studies[4]. In this study among the fatal cases all the pilots (100%) had head injury. Transmission of the impact forces through the mandible and temporo-mandibular joint to the base of the skull results in a transverse fracture that runs forward from the joint anterior and parallel to the petrous temporal bone, sometimes known as the “hinge fracture”. Fracture of the base (ring fracture) is a result of the forces being transmitted through the vertebral column and is found particularly with +Gz deceleration. These severe vertical forces are seen in falls from a height and when aircraft descend vertically in situation such as a stall. In severe cases the forces may cause secondary “blow-out” fractures of the vault of the skull[5]. The predominance of decelerative injuries, in particular, head injury, in aviation related fatalities calls for more effective restrain system, such as shoulder harnesses for all occupants or improved seat design. Restraint failure or inadequacy of restraints has long been recognized as one of the principal sources of mechanical injury in aviation crashes[6]. In our study, considering the site of injury all the pilots had thoracic spine compression fracture (100%). Injury to the heart and aorta also arise by direct penetration by the broken ends of ribs. However, flexion injuries can also compress the chest as the chin falls forward and strikes the sternum – the so called “chin-sternum-heart syndrome”, which was originally described in parachuting accidents[7]. In this study seven victims (70%) had ruptured diaphragm, 6(60%) had ruptured liver, 5(50%) had ruptured spleen, 2(20%) pilots had ruptured kidneys and urinary bladder. The injuries that are sustained may mirror the shape of the controls involved and depend on the direction and magnitude of the forces that are applied. The injury caused by flailing of a hand that is manipulating the throttle is, in contrast, seen on the dorsal aspect between the wrist and the knuckles[8]. Long bones are most susceptible to bending injuries while short bones can withstand stress but are most affected by crushing. Impact injuries cause the greatest damage to flat bones[9]. Longitudinal forces occur during many crashes. They may be accompanied by collapse of the cockpit structure with injury to the occupant's legs leading to incapacity and failure to escape. It is believed that a negative acceleration or deceleration (-Gx, ‘eyeballs out’) of 45G may be sustained for a short period and 25G for longer without incapacitating injury[10]. In many crashes where the pilot cannot eject in time, the aircraft structure collapses and the individual is injured by impact with the airframe. These injuries can include amputations, major lacerations and crushing. The cause of death in these cases was the combined effect of sudden deceleration and the high terminal velocity impact of the aircraft striking the ground. The injuries were produced by a vertical transmission of force from the buttocks upwards causing extensive visceral damage. Simultaneous deceleration force would cause rupture of heart and multiple fractures of ribs and extremities. In a study by Wiegmann DA and Taneja N[11], in 2003 it was found that the most commonly occurring bony injuries were fracture of the ribs (72.3%), skull (55.1%), facial bones (49.4%), tibia (37.9%) and pelvis (36.0%). Common organ injuries included laceration of the liver (48.1%), lung (37.6%) heart (35.6%), and spleen (30.1%), and haemorrhage of the brain (33.3%) and lung (32.9%). In a similar study by Li G and Baker SP[12] in 1997, multiple injuries were listed as the immediate cause of death in 42% of the fatalities, followed by head injury (22%); internal injury of thorax, abdomen or pelvis (12%), burns (4%) and drowning (3%). The majority (86%) died at the scene or was dead on arrival at the hospital. Eighteen percent of the victims were reported to have sustained a single injury, with head injury being the cause of death in nearly a third of these fatalities.

Common organ injuries included laceration of the liver (48.1%), lung (37.6%) heart (35.6%), and spleen (30.1%), and haemorrhage of the brain (33.3%) and lung (32.9%). Shkrum MJ et.al[13] in 1996 showed in their study that passengers sustained relatively more craniofacial fracture and abdominal/retroperitoneal trauma in the accident. Pilot error was the most frequent cause of crashes, followed by mechanical failure and adverse weather/environmental conditions. Results of these studies are almost similar with that of our study. In our neighboring country India 39 fighter aircraft and choppers of the Indian Air Force (IAF) and the Navy have crashed during the year of 2007 to August 2010. The IAF lost 13 qualified pilots in these crashes. Some 290 non combatant accidents have taken place in which 120 rookie and trained pilots of IAF have died over the past decade involving Soviet made MIG-21, Jaguars and Sukhoi aircrafts[14]. This number is much higher than that of BAF fighter crashes, possibly because we have less number of aircrafts and these are maintained very carefully as routine operational matter.

A study shows that in Royal Australian Air Force (RAAF) between 1951 and 1992, 84 aircrews ejected from their aircraft with 77 survivors and 7 fatalities. Vertebral fractures (35%) were most common type of injury[15]. Another study shows that from 1981- 1997 there were 86 ejections from 56 aircrafts in German Air Force, in which 12(14%) were uninjured, 41(48.2%) were slightly injured and 30(35.3%) severely injured. Commonest injury was vertebral fracture followed by lower limb injury due to parachute landing fall[16]. These results are similar with those of our study.The greatest risk occurs between Tl0 and L2. Injuries at other levels are rare and usually related to forward flexion as a result of poor posture. The injuries are either anterior lip chip fractures or compression fractures of the vertebral body. Spinal cord involvement is rare[17]. Various studies have suggested that fighter aircrews are more susceptible to develop disc disease and spinal injuries whereas helicopter aircrews are more likely to develop low backache, spondylolysis and spondylolisthesis.

During ejection from fighter aircraft, large Gz forces act in the buttock to head direction in the long axis of the spine. As a result, the most common type of vertebral fracture seen during ejection is the anterior wedge compression fracture. It is estimated that radiographic evidence of fracture can be found in 30 to 50 per cent of aircrew after ejection. Any degree of flexion in the posture of the seat occupant enhances the risk of spinal injury. Current research efforts are being directed toward solving the problems associated with high speed and high altitude ejections. Pilots and other crew who work in the cockpit of aircraft equipped with egress systems have to receive training on the egress system and ejection seat so that they are fully familiar with the system and can use it safely. The system simulates ejection by moving the canopy open as if jettisoned and rising the seat approximately 18 inches up the rails when the system is manipulated correctly. The primary use of such a simulation is to provide the aircrew with the confidence that the system works as advertized and to familiarize them with the motions and timing needed for a successful egress. Due to nature of the ejection process, without an EST (Ejection Seat Training), pilots will never be able to prepare themselves to face emergency safely without sacrificing expensive equipment or worse, putting their own lives in danger.

Conclusion

There were certain drawbacks in this study which stem from the inadequate data available for analysis. There was no documented data regarding spinal injury involving the non fatal cases or any post ejection evaluation of spinal injury in BAF aircrew who had history of ejection. It is suggested that for the purpose of standardized data collection, documentation of each clinical record should be mandatory. Use of injury severity scoring system will help in categorizing injury so that attention could be focused on severe injuries. Preflight mandatory medical examination of pilot and co-pilot should be conducted carefully. Protective measures and training among aircrews should be updated, so that less injury occurs in survivors. Thorough medical diagnosis and

psychological treatment are required for the injured aircrews. There is a need to consider the development of a device which may be useful in reducing flailing of body parts and extreme flexion of the body during sudden deceleration occurring in aircraft crashes.

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