Case Report

Medical aspects of a fatal aircraft accident investigation

Sqn Ldr Deepak Gaur

Graded Specialist (Av Med)
30 Squadron, Air Force C/o 99 APO

An important aspect of the aeromedical investigation into a fatal aircraft accident is establishing whether any injuries were ante mortem. This is important to rule out sabotage or incapacitation of the pilot prior to final impact. It can also help in establishing the sequence of events in the accident. Surgical emphysema of the thorax and neck can only occur in ante mortem injury to the lung parenchyma including a major bronchus. A review of classical textbooks of Forensic Medicine and Aviation Pathology did not not reveal any use of the evidence of surgical emphysema to prove an ante mortem injury. The paper discusses the importance of a well conducted autopsy and whole body X rays in a fatal aircraft accident. In an accident on Type-77 ac in the Eastern Sector in April '96, it was apparent that the seat automatics had failed. The seat-man separation and not take place and the pilot was found dead in the seat in the semi closed capsule. History of the seat revealed that it had been removed from an accidented aircraft at HAL. This led to the court of enquiry to think on the lines of pre existing damage of the seat. The medical part of the investigation helped prove beyond doubt that the pilot had sustained ante mortem injuries when a part of the seat structure broke in the air at the time of main-gun firing. This helped to establish the sequence of events which led to failure of seat-man separation.

Key words : Surgical emphysema, Aircraft accident, Accident investigation

The role of the aeromedical specialist in an aircraft accident investigation cannot be over-emphasised. This fact assumes even greater significance in case of a fatal accident where the pilot is not alive to tell his tale. The medical officer who first reaches the crash site, as also the one who conducts the autopsy, can provide valuable clues to assist the Court of Inquiry. Whole body X-ray examination of the victim is a mandatory requirement; but may not always be carried out with meticulous care, as it may not provide any unexpected finding. This paper is presented to highlight the importance of each step of the aeromedical investigation in a fatal aircraft accident. The forensic evidence of ante-mortem injuries includes bone marrow emboli, large haematomas and evidence of inflammatory changes in the surrounding tissue. This paper also discusses the presence of surgical emphysema of the thorax and neck as a positive indicator of ante-mortem injury.

The accident

In April 1996, an experienced pilot was leading a MiG-21 Type-77 two aircraft low level strike as part of a routine exercise in a training squadron. The formation took off at 0843 hours and did a couple of NATO turns. When flying at 200 m above ground level at approximately 700 kmph IAS, the leader gave a call for 100%. Fifteen seconds later, at 0903 hours the leader called to say he had had a flame out and was attempting relight. This was followed by a call - "Relight

unsuccessful - Ejecting". His No. 2 saw the doomed aircraft rock its wings. He, however, did not see any parachute open. A rescue helicopter was launched immediately. On reaching the site, the medical officer found the pilot dead in the semi closed seat-canopy capsule. The pilot had apparently sustained severe decelerative injuries including head injury. The body was taken to the hospital where whole body X-ray examination was carried out at about 1230 hours and an autopsy was performed the same afternoon. Specimens for toxicological analysis for carbon monoxide and alcohol and for histopathological examination were dispatched to Institute of Aerospace Medicine, Bangalore (IAM) by aircraft, the next day.

The investigation

This was apparently the first documented case of ejection seat failure in this type of aircraft and the initial concern of the Court of Inquiry was to establish the cause of seat failure and then examine the aspect of engine failure. It was important to quickly establish the reasons for failure of the seat in order to restore the faith of aircrew especially in the ejection system.

The SK-1 Seat. MiG 21FL (Type 77), being the first supersonic aircraft designed by the Mikoyan Guryevic Bureau, the designers had opted for semi closed capsular ejection in order to prevent the expected (but later disproved) injuries during ejection due to ram air at high speeds. The pilot uses either or both the seat handle levers to initiate the ejection. There are two distinct movements of the levers. The initial part results in jettisoning of the canopy. The second part initiates seat ejection. The following sequence takes place : automatic foot restraining, inertia reel locking, drogue gun firing, followed by main gun firing. As the seat moves up by 20 mm the canopy comes to rest on the seat trunnions. With further upward movement of the seat, the canopy slides over and encloses the pilot from the front, locking on both sides with the lower front portion of the seat. During the upward movement of the seat, a mechanical timer-AD-3, gets activated because of pulling out of a cotter pin attached to the bulk head by a snap hook. The AD-3, after 1.5 seconds delay, fires the 'F' guns on either side of the seat. These guns in turn move bell cranks which further bring about the following events through mechanical linkages:-

(a) Separation of the drogue gun

(b) Releasing pilots harness

(c) Releasing leg restraints

(d) Opening front locks of the canopy

(e) Moving the rear levers to allow detachment of canopy after opening through 120° approx.

Should the AD-3 fail to function, the 'F' gun firing and the rest of the sequence can be initiated by the manual separation handle. With the front locks open, the air stream forces the canopy to lift up and when it opens beyond 1200 knots, it disengages and flies away. Since the pilot is also now unharnessed, the differential drag produces seat-man separation. This separation releases a cotter pin from the pilot parachute of the main parachute, in turn helping to deploy the main parachute. Seat-man separation may have to be facilitated by a push to the seat by the pilot.

When the seat moves up and the canopy engages the trunnions, the force of the rapidly rising seat and that due to the weight of the canopy is transmitted to the seat through magnesium alloy crossbeam members on either side of the seat back. The ejection minima for this seat are 110/130. (110 meters altitude at speeds less than 500 kmph).

The evidence

The following salient features emerged from the statements of witnesses and the material evidence:

(a) The ejection was initiated well above the seat minima.

(b) The seat automatics for separation of the canopy had failed.

(c) The cast magnesium alloy cross beam had broken on the right side.

(d) The seat-man-canopy capsule had impacted the ground on the left side producing majority of injuries to the left half of the body.

(e) The drogue chute had not deployed and the seat had tumbled before impacting. The drogue gun was found wrenched out near the seat.

(f) Both hands of the pilots were injured in a pattern suggesting that he was holding the manual separation handle on the seat pan. However, the handle had not been operated, with locking wire intact.

(g) The F-guns had fired on both sides.

The deliberations

With ejection below minima ruled out, the main suspicion now lay with the malfunctioning of the AD-3. The Court of Inquiry made another visit to the main crash site to confirm the attachment of the snap hook on the bulkhead. This was found intact and inadvertent non-connection of the cable by the ground crew was ruled out. The AD-3 timer was removed and checked for functioning of the timer which was found to be fully functional despite the crash forces. One time delay/failure of the AD-3 was thought improbable by the Court since it is a simple mechanical timing device with spring mounted trigger switch.

Pre-existing damage to seat

The dilemma persisted till the technical member discovered that the ejection seat in question had been cannibalized from an aircraft which had met with a nose wheel collapse accident in 1987. The line of thinking now changed to looking for pre-existing damage to the seat. Since the seat automatics had functioned well till the separation process, it was deduced that a part of the seat structure may have broken in the air on the firing of the main gun. The cast magnesium cross piece on the right side which was earlier presumed to have broken on final impact with ground could have broken in the air at the time of main gun firing in view of the fact that it may have been damaged in the previous accident. This hypothesis could have explained the rest of the events which followed, i.e. the non-opening of the front canopy locks, the restrained position of the pilot, the unopened right leg restraint and the drogue gun falling off at the point of seat impact. The non-deployment of the main parachute and the death of the pilot was the expected consequence.

Timing of Fracture of Magnesium Alloy

Cross Piece: The Court required evidence to time the breaking of the magnesium alloy cross piece. If evidence could be found to show that the damage was at the time of main gun firing then the failure of the canopy to separate could be explained fully. As a step in this direction, a two pronged effort was taken up by the Court. This consisted primarily of the medical evidence

Ante mortem vs post mortem injury

The post mortem X-ray films of the pilot's body had revealed multiple fractures mainly on the left side of the body. However, the X-ray chest also showed fracture ribs 2nd to 8th on the right side. These ribs were fractured both posteriorly and on the lateral aspect. There was also evidence of pneumo thorax on the right side and bilateral surgical emphysema of the thorax. The posterior line of rib fractures on the right side corroborated with the broken cross beam on the right side. If the cross beam had broken in the air at the time of main gun firing, the rib fractures on the right side would have been ante-mortem, since the pilot would have survived that injury for about 20-25 seconds before impacting the ground and dying.

The sections of the lungs examined at IAM did not show any evidence of bone marrow or fat emboli. The Aviation Pathologist was of the opinion that the fractures from the ribs might have not produced any emboli because of very small amounts of marrow and absence of large sinuses to carry emboli.

Surgical Emphysema. The finding of surgical emphysema on the chest X-ray film of the deceased pilot was confirmed by two independent radiologists. Whether surgical emphysema could be caused only by an ante-mortem injury, or it could also be produced by post mortem injury to the chest wall, was discussed extensively between specialists in Aviation Medicine, Pathology and Forensic Medicine. Standard textbooks of Aviation Pathology and Forensic Medicine did not reveal any information on this. The consensus of the opinion was that surgical emphysema of the thorax and neck could occur only in an ante-mortem injury to the chest involving fracture of ribs which could pierce a major bronchus. Only positive pressure in the lungs due to breathing could force air from the lungs into the subcutaneous tissue planes. At the instant of death due to severe crush injuries on the chest, surgical emphysema may occur if the large escape route of the air - the trachea and mouth - are obstructed. In this case there was no evidence of any such obstruction/ injury. Hence presence of surgical emphysema of the thorax and neck confirmed that the injury to the ribs on the right side was ante-mortem.

Technical support of medical inferences

This theory was further confirmed when tests on the broken seat at the National Aerospace Laboratories Bangalore (NAL), revealed 'locked in stress', to the guide rails. This was because of the previous accident. These stresses got released with the main gun firing and led to the breaking of the cross beam. Also the cast magnesium alloy cross piece was found to contain 'dross' elements which made the structure inherently weak. The Material Sciences experts at NAL were of the opinion that the cross beam must have broken in the air at the time of main gun

firing.

Conclusion

It was a dedicated team effort that helped solve the riddle as to why the seat failed. Such a failure would not have occurred provided it was ensured that seats were not cannibalized from aircraft involved in accident. The lessons learnt by the aeromedical fraternity would be to take each step of an aircraft accident investigation with utmost seriousness. Despite taking more than three hours on the autopsy, the clinical finding of surgical emphysema had been missed. It is easy to fall prey to assumptions in the initial stages of the medical investigation. If one does not suspect any ante-mortem injury one does not look for it. The need to carry out whole body X-ray examination of victims of fatal aircraft accidents stands fully vindicated. Surgical emphysema deserves to be added to the list of evidence that suggest ante mortem injuries. The fact that the medical and forensic evidence was paramount in determining the cause of the accident should serve as an incentive for all investigators to be more meticulous and methodical when investigating an aircraft accident.