Review Article

Aeromedical aspects in aircraft mishap investigation and prevention (AMIP): The practice in USAF

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The endeavour of an aircraft mishap investigator in any airforce of the world is to determine the cause of accident, the sequence of events and effects of the accident, with a final aim to avert a similar accident in future. This effort forms the basis of accident prevention, i.e., identification of risk factors and their control or elimination. The paper reviews the current teachings and practice of the aeromedical aspects in AMIP in the USAF, with emphasis on human factors, life support systems and standardised documentation procedures.

Keywords: Aircraft accident, human factors, flight safety.

Aircraft mishaps generally involve combinations of human, mechanical and environmental factors. A USAF safety investigation board has a full spectrum of expertise. Its voting membership includes a flight surgeon as well a pilot, safety and maintenance officers. The flight surgeon is best qualified to consolidate an analysis of human factors in terms of physical, physiological and psychological processes and their role in the disruption of the 'human-aircraft' interface. With the help of a life-support officer he or she can evaluate life-support equipment and the concerns with functioning of equipment during escape, survival and rescue.

USAF Aircraft Mishap Classification

Individual mishaps are classified into the following categories according to total cost, levels of injury or loss of work days [1,2]. These categories apply for both aircraft and ground mishaps:

(a) Class A:

(i) Total cost of $ 1,000,000 or more; or

(ii) A fatality or permanent total injury or

(iii) Destruction / damage beyond economical repair to ac.

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(b) *Class B :*

(i) Total cost of $ 200,000 or more, but less than $ 1,000,000; or

(ii) A permanent partial disability; or

(iii) Hospitalisation for 5 or more personnel.

(c) *Class C:*

(i) Total cost of $ 10,000 or more, but less than $ 200,000; or

(ii) An injury resulting in a lost workday (ie 8 hours or greater).

(d) *Class D:*

(i) Total cost of less than $ 10,000; or

(ii) A nonfatal case without a lost workday.

Physiological Incidents

USAF policy defines a physiological episode as "in-flight events of a physical, medical, pathological, psychological, pharmacological or toxicological nature which compromise performance, confuse, disorient, dull, distract, pain, endanger or incapacitate." This is categorized as a Class C Mishap even when no damage or loss of workdays occurs. There are subdivisions within this category, some of which require standard reports (Life Sciences Report of a Class C Physiologic Mishap) and others requiring an abbreviated version. Hypoxic hypoxia, decompression sickness, and G-induced loss of consciousness require a standard report. An abbreviated report may be submitted by the flight surgeon for such things as hyperventilation, spatial disorientation and toxic substances in the cockpit.

Objectives of Aeromedical Investigation

The USAF has laid down five main objectives in the medical investigation of aircraft accidents:

(a) Identification of the deceased: Identification is based on scientific method (fingerprint, footprint, dental or DNA comparison), rather than personal effects or personal recognition which have proven unreliable.

(b) Reconstruction of the crash circumstances: By studying the distribution of remains and analysing the pattern of injury of each victim, the events immediately preceding, during and following the crash can be reconstructed.

(c) Determination of medical facts as major or minor factors in the cause of the crash: Autopsy of the crew is performed to search for any pre-existing or concurrent disease. Blood alcohol, carbon monoxide, and drug screening tests are a must from aircrew fatalities and aircrew survivors for all class A and B mishaps respectively. In general, urine or blood is screened for presence of drugs or metabolites. Tests are then performed on blood or tissues to confirm the presence and amount of a specific drug found positive on screening. Vitreous humor from the intact eye is obtained to confirm the presence of ante-mortem ingestion of alcohol. The laboratory tests (Table 1) are done at the Armed Forces Institute of Pathology (AFIP) at Washington D.C.

(d) Analysis of structure and design in relation to injury and death: This information is useful in the design of new aircraft, life support systems and in the modification of those already in the inventory.

(e) Collection and preparation of teaching materials: Information collected here is used by AFIP, the School of Aerospace Medicine, the National Transportation Safety Board etc. to complete statistics and to train pilots, aircrew, accident investigators and aviation medicine specialists.

Table 1: AFIP Drug Screen

Drugs of Abuse: amphetamines, barbiturates, benzodiazepines, cannabinoids (THC), cocaine, opiates, etc.
Other drug classes: acetaminophen, antidepressants, antihistamines, choloroquine, lidocaine, mefloquine, narcotic analgesics, phenothiazines, phenytoin, salicylates, sympathomimetic amines, verapamil, etc.

Phases of Medical Investigation

The phases of medical investigation fall into five time-sequenced categories: investigation readiness, initial medical response, medical and psychological data consolidation, team analysis and reporting.

Investigation Readiness

(a) Response Requirements: The Chief of Aerospace Medicine in a flying wing maintains the capability to respond to mishaps. His responsibilities include maintaining a regularly trained staff who understand disaster medicine and safety investigation. This includes not only aeromedical services staff, but also laboratory, X-ray and ambulance response staff. He or she also maintains liaison with other agencies such as safety, fire, rescue, security, photography, AFIP, mortuary affairs, local hospital, major command etc.

(b) *Mishap-response kit:* Aeromedical services maintain a properly configured mishap-response kit tailored to local needs as well as a properly configured ambulance. Sample inventory of Medical Equipment for crash ambulance includes the following:

AMBU Kit (1); Blankets (8); Burnpack Sterile (1); Cervical Spine Board (1); Full Spine Board (1); Triage Flags (1); Litters (4); O_2 Bottle, Regulator and Mask (1); Remains Bags (5); Suture Set (1); Restraints (2); Sand Bags (2); Thomas Leg Splint (2); Air Splints (2); Plastic Splints (1); Wire Splint (3); Wood Splint (5); Aluminium Foil (1); First Aid Kit (1); IV Fluids Equipment.

(c) *Training of Medical Staff:* Training of medical staff begins with the flight surgeon's training as part of the Aerospace Medicine Primary Course. Following appointment to a rated post the flight surgeon is qualified to be a voting member of a safety investigation board. He or she then undertakes periodic

training review under the local safety office. In addition they undergo the Aircraft Mishap Investigation and Prevention Course at Brooks AFB, and a course in human behavioural psychology. Disaster-response and safety investigation procedures training is also imparted to aeromedical technicians, laboratory and X-ray staff. The ambulance response crews are trained for general survior care, triage, specimen and evidence management and immediate aerospace medicine assistance.

(d) *Initial/Interim Medical Response:* The safety investigative effort begins for the flight surgeon with mishap notification. The first flight surgeon to arrive at the mishap scene is usually appointed to the Interim Board by the Wing Safety Office. The mishap response and initial actions become part of the Permanent Board flight surgeon's report. The activities during the initial response include:

(i) Notification of estimated time of mishap, location coordinates, souls on board and casualties and any information concerning weapons, toxic substances and composite materials on board.

(ii) Organisation of SAR mission with focus on recovery and treatment of survivors. The universal prophylaxis for all recovery crew at the crash site is very strictly enforced, especially in mass casual situations.

(iii) On recovery, actions on Aircrew Survivors include the following:

(aa) Secure medical and dental records.

(ab) Secure life support gear (including clothing) and egress equipment.

(ac) Treat injuries and perform physical examination.

(ad) Perform spinal X-rays in cases of ejection.

(ae) Obtain specimens for toxicology, alcohol and carboxyhaemoglobin analysis.

(af) Initiate 72 hour and 14 day prior to mishap histories. 72 hour history focuses on crew rest, diet and stressors; needs to be detailed with times, activities, content of meals. 14 day history is more general and focuses on changes in routine.

(ag) Perform toxicology, 72 hour history and 14 day history on anyone else possibly a factor in the mishap, eg. Air Traffic Controller.

(iv) In case of Aircrew Fatalities the flight surgeon is responsible for the following:

(aa) Each remains and dismembered portion is tagged, staked, photographed and plotted on the remains location sketch.

(ab) An intact body is photographed and X-rayed in full life support gear with special attention to head, neck, hands, feet and spine. When dealing with fatal ejection neck or head-neck injuries, a lateral view of occipital-first-cervical with the head under 25 pounds of traction is required.

(ac) X-ray of clothing, helmet and boots is done after they are removed at autospy.

(ad) Establish identification of the victim; dental ID is best, finger or footprint records can be used. DNA testing is now available and DNA

records on all military flying personnel are being maintained. When needed, these DNA tests can be forwarded to AFIP to compare with DNA testing on autospy remains.

(ae) Obtain permission, arrange and witness the autospy. Autopsies are required on all crew members operating the aircraft. AFIP pathologist with a trained photographer is generally available at the autospy.

(af) Collect, preserve and despatch the laboratory and toxicological specimens to AFIP.

(ag) Life support equipment, specifically garments removed during autospy are sprayed with Lysol and stored in a ventilated room, to be used during accident reconstruction.

(v) The flight surgeon is expected to preempt psychological impact on the initial responders to the crash scene. He arranges a Critical Incident Debriefing or counselling by qualified mental health staff if required.

Medical Data Consolidation

The data consolidation phase involves witness and survivor interviews, review of the personal/ medical history and consolidation of on-the crash-site and autospy findings. To ensure a well planned and standardised reporting, the USAF has designed the Safety Investigation Workbook for the flight surgeons, to be used during the investigation. This descriptive workbook addresses the 'Human Factors' in terms of the human performance issues and environmentally oriented issues and covers all phases of the accident investigation process. It also includes a standardised spouse or friend interview guide and an injury worksheet.

Human factors Team Analysis

Once the mishap sequence of events is known and investigation has identified probable causes, all the board members participate to assess many complex human factors involved in a mishap. The flight surgeon assumes the role of case manager. He/she prepares a list of potential human factors and initiates consultation with other board members to rate each factor's contribution to the mishap. Technical assistance to the flight surgeon is available in the areas of life support, human performance, egress and survival. The human factors consultants include the following: -

(a) Life Support Officer (aircrew equipment, egress, survival)

(b) Aerospace Physiologist (human performance, environmental factors, crash dynamics)

(c) Aerospace Psychologist (psychosocial factors)

(d) Mr. Michael Grost, Life Sciences Equipment Lab, Kelly AFB (life support equipment).

The Formal Report

The formal report of the safety investigation board is divided into two parts. Part I contains factual information, which may be disclosed outside Air Force (unlimited use). Part II contains privileged information including findings and conclusions of the board, its technical consultants and medical information. The flight surgeon, with the assistance of the life support officer completes the form on 'Life Sciences Report of an Individual involved in an Accident/

Incident'. This exhaustive and objective report has a standardised reporting format for all aspects of egress, ejection, search, rescue, survival, related equipment or training, physiological, medical and injury data. Human performance and environmental factors (both in air and ground) are addressed on a five point contribution scale (0 = present but not relevant to mishap, 4 = causal). This report is now available in a interactive windows-based computerised format for easy and quick preparation and retrieval. In addition the medical report also contains a narrative, using a standard glossary of terms, focussing on factors contributing to the mishap. The narrative discusses the mishap scenario, egress, search and rescue, injuries, aeromedical background, work and rest history and human and environmental factors.

Conclusion

The Air Force continuously attempts to develop effective programmes to prevent mishaps and protect personnel. Equipment or programme designers turn to medical data to find historical information which may suggest and help to prioritize correct solutions. The primary area of concern for a flight surgeon as a board member is identifying various human factors which might have played a part in the mishap. A systematic investigation with standardised reporting and effective data-retrieval system are the key to flight safety.

References

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2. Lecture Notes: *Aircraft Mishap Investigation and Prevention Course*. USAF School of Aerospace Medicine, 1997.