Original Article

Retrospective analysis of fatal aircraft accident investigations during the period 1975-2004 : A reality check

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ABSTRACT

Fatal aircraft accidents impose immense loss to the nation in terms of loss of precious life and costly equipment. Each such accident is followed by a comprehensive investigation, which includes aspects ranging from the technical data to human factors. The aim of these investigations is to arrive at a logical sequence of events that could have resulted in the accident. The present study analyzed the medical investigations performed in the Department of Aviation Pathology at the Institute of Aerospace Medicine, Bangalore, during the period 1975 to 2004. Data collection for this study was done from available IAFF (MS) 1956 records. Data regarding gross pathology and histopathology findings in each case and toxicology results (if available) was tabulated and analyzed. A total of 452 fatalities in 289 aircraft accidents (which included 343 pilots and 109 other crew/ passengers) were studied. Fighter aircraft of various types accounted for 75% of all fatal aircraft accidents. A majority of these occurred in mid-air (84%). Postmortem examination was performed on 89.8% of fatalities. Military pathologists performed the autopsy in approximately 91% of the accidents. Polytrauma with vital organ injury was the most commonly encountered gross pathology finding on post mortem examination. Traumatic pneumonosis (74.8%) and hemorrhage in vital organs (43%) were the common histopathological findings. Toxicological analysis did not reveal the presence of alcohol in any sample. Though most of the findings in the present study conform to the observations of previous studies, the occasional variance of findings necessitate consideration of suggestions to make the present system of medical examination of aircraft accident investigations more meaningful and practical.

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Aviation is a highly skilled task that demands a perfect coordination of man and machine to complete the mission undertaken. Any fatal aircraft accident imposes a substantial blow in terms of loss of trained pilot/ crew and of sophisticated costly aircraft to any organization or nation. An in-depth analysis of all factors and aspects leading to any such catastrophe is mandatory and should be done to pinpoint the exact cause of accident in order to prevent any future accidents. In India, all aviation accidents are investigated in detail, either by the military or Director General Civil Aviation (DGCA). The medical aspects are analyzed centrally at the Institute of Aerospace Medicine (IAM) Bangalore. The aim of this study was to carry out an analysis of the medical investigations in fatal aircraft accidents in the past 30 years.

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Material and Methods

The following material were studied to compile the data for analysis:-

(a) IAFF(MS) 1956 (Medical Report on Major Aircraft Accident)

(b) Details of conduct of autopsy

(c) Gross autopsy findings

(d) Histopathological findings on tissues submitted for analysis

(e) Toxicology reports and

(f) Available histology slides filed at IAM IAF, Bangalore.

Various parameters that were analysed were as follows:-

(a) Type of aircraft involved

(b) Age of the pilot

(c) Phase of flight in which the accident occurred

(d) Major injuries sustained including burns

(e) Autopsy details

(f) Histological correlation

(g) Results of toxicological tests

Results and Discussion

The total number and types of aircrafts involved in fatal accidents during this period are as shown in Table 1.

Table 1: Types of aircraft involved

Type of aircraft	Percentage
Fighter / Bomber / Trainer	75.4%
Transport	7.2%
Helicopter	16%
Not available	0.7%

Fighter aircraft formed the bulk of these accidents (75%). The type of aircraft was not mentioned in the documents in two accidents (both were investigated by DGCA).

Age of the pilots/crew. The age of pilots involved in these fatal accidents ranged from 21-55 years. Average age was 29.5 years. In 11 cases exact age was not mentioned in the documents available. Details are as given in Table 2.

Table 2 : Age of Aircrew

Age range in years	No. of pilots (%)
21-25	101 (29.4)
26-30	101 (29.4)
30-35	76 (22.15)
36-40	34 (9.9)
41-45	17 (4.9)
46-50	3 (0.8)
Above 50	6 (1.7)
Not available	11 (3.2)
Total	343

Majority of involved aircrew were less than 30 years old (58.8%). There is an evident shift towards older age range as compared to previous studies conducted by Mathur et al. and Sirpal [1,2].

Phase of flight. The details of phase of flight in which the accidents occurred are given in Table 3.

Table 3 : Phase of flight

Phase of flight	No. of aircrafts (%)
Take off	20 (6.9%)
Landing	25 (8.6%)
In-flight (including mid air collision, loss of control, explosion/ fire / break up in air due to unknown cause)	243 (84%)
Taxiing	01 (0.34%)
Total	289

The combined incidence of accidents during take off and landing was 15% in contrast with the common misconception that majority of accidents

occur during take off or landing. These findings also corroborate with earlier studies Mathur and Sirpal et al. [1,2].

Salient findings of initial autopsy investigations. Autopsy on the bodies of victims was performed in 406 cases (89.8%). A small number (n=46, 10.17%) of victims were not subjected to any such examination either due to total disintegration of the body or due to non-recovery of any body parts. This finding compares closely with the study of Mathur et al. who had recorded an autopsy rate of 79% in their study [1]. This also is in contradiction with the common belief that aviation trauma is always too extensive for any useful histological information or toxicology. Initial autopsy and gross examination of the injuries was conducted by military pathologists from the nearest military hospital in 370 (91.13%) cases under the supervision of aviation medicine specialist or the unit SMO. Out of the other 36 remaining cases, 30 (7.3%) were conducted by civil surgeons / pathologists and six by non -specialist medical officers. Photographic details, either of the crash site or of the bodies of victims were available in 115 cases (25.4%). Histopathological analysis was carried out for 386 (85%) cases only as tissues were either not recovered or were decomposed in transit for the other 15%.

Details of injury analysis from description of gross autopsy findings. Cause of death as recorded in the documents is described in Table 4. Multiple causes and overlap of injuries was a common finding in this study. As is evident, polytrauma and injury to vital organs like heart and lungs claimed the maximum number of casualities (72%). This group was followed by head injury with or without accompanying spinal injury (8%) and hemorrhagic shock (4.4%). Two cases of drowning were proved by demonstration of diatoms in lungs in crashes that had occurred over water bodies. The findings of the present study are similiar to those of earlier series where polytrauma was the most commonly reported cause of death [1,2].

Salient histological findings

Traumatic pneumonosis due to injury to lungs remained the commonest finding in examination carried out for 386 victims and was documented in 289 (74.8%) incidents. Mathur et al. have reported this incidence to be as high as 92.3% in the aircrew from fighter stream and 75% in aircrew of transport aircraft [1]. This was usually following severe decelerative trauma. Emboli in

Table 4 : Injury Patterns

Injury type	Fighters	Helicopters	Transport	No. (%)
Polytrauma with vital organ injury	147	84	95	326 (72%)
Head injury with without Spinal injury	27	12	1	40 (8%)
Burns	1	13	4	18 (3.9%)
Hemorrhage and shock	11	3	6	20 (4.4)
Drowning	1	1	-	2 (0.4%)
Unknown	40	5	1	46 (10.17%)

lungs and other organs were seen in 162 (41.9%) cases and signified a patent circulation following severe bony trauma, which finally resulted in death due to hemorrhage and shock.

Hemorrhage in vital organs was also a common finding. Lungs, liver, heart and spleen were commonly involved. Varying grades of coronary atherosclerosis was observed in 189 (48.9%) out of the 386 cases. These include both aircrew and passengers. Mason has graded these changes from 1 to 3 as follows:-

Grade 1- Atheromatous plaque leaving adequate lumen (50% or less narrowing)

Grade 2-Atheromatous plaque with severe reduction of lumen

Grade 3 - Atheromatous plaque with degenerative changes particularly calcification and or complete occlusion of lumen [3,4].

Table 5 : Details of Coronary Atherosclerosis

Grade of Atherosclerosis	No. of cases (%)
0 (normal coronaries)	197 (51.1%)
Grade I	104 (26.9%)
Grade II	78 (20.2%)
Grade III	7 (1.8%)

Of the seven grade III coronary atherosclerosis, one was a case of coronary artery stenting done in a senior army officer who was a passenger in a helicopter crash.

Incidental histological findings observed in aircrew are given in Table 6. None of these pathologies could have caused the crash except for focal myocarditis [5] and pleuropulmonary tuberculosis, where a cardiac emergency is a clinically accepted possibility.

Toxicological studies

Samples of blood, brain and muscle are routinely sent to IAM for carrying out analysis of alcohol levels, lactic acid and carbon monoxide levels. Out of the 264 samples sent, carbon monoxide levels were high in 7 cases and indicated antemortem burns/ inhalation of smoke in closed confines. Lactic acid was found elevated in only three cases indicating hypoxia during flight. Alcohol levels were never detected as high/ elevated. Earlier studies have documented a similar finding [1,2].

Table 6 : Incidental histological findings in aircrew

Finding	No. of cases
Focal myocarditis	01
Fatty change in liver	03
Evidence of viral hepatitis	02
Pleuro pulmonary tuberculosis	01
Lymphocytic thyroiditis	01
Early cirrhosis	01
Chronic nonspecific thyroiditis	01
Bilateral chronic pyelonephritis	01

Some countries mandate a comprehensive drug screen including estimation of blood levels of commonly prescribed drugs such as oral hypoglycemics and antihypertensives [6]. This could be looked into for our set up in addition to the existing practice of conducting toxicological tests for carbon monoxide, alcohol and lactic acid.

Details of accident scenarios

Photographic details and /or SMO's narrative of the crash events were available in 289 (63.7%) cases. Many photographs were taken either in the mortuary where autopsy was conducted or after the body was removed away from the crash site. Hence, important clues like hyper- flexion injuries, fouling of ejection systems and failure of protective clothing like helmet and boots may have been overlooked.

Conclusion

Aviation accident analysis is a complicated task, which requires dedicated and committed set up and trained manpower both, at the peripheral units and at IAM, Bangalore. Although detailed standard operating procedures regarding conduct of such autopsies are available, the requirement is to follow them strictly and efficiently. The need to sensitize and train all in-service pathologists in this field cannot be over emphasized. Since service pathologists from any of the three services (Army, Navy and Air force) may be called upon to conduct autopsies following aircraft accidents, it is suggested that aircraft accident investigation (including specific training on conduct of such autopsies) be given due emphasis during their post graduate training. Digital technology should be used to record and collect data for a comprehensive analysis of injury and injury patterns. Toxicological screen must be extended to include commonly used drugs and detect cases of self-medication.

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