Original Article

Retrospective analysis of autopsy investigation: fatal aircraft accidents (1988-1999)

Wg Cdr YM Sirpal*

ABSTRACT

Human factors play an important part in the causation of aircraft accidents. A retrospective a of autopsies on aircrew involved in fatal aircraft accidents belonging to the three wings of Armed of India from January 1988 to December 1999 has been done utilizing autopsy details, histopath and toxicological data, recordings in the document of medical report on major aircraft acc findings of court of inquiry (if available) and medical report from senior medical officer. One h twenty seven air crash resulted in 187 aircrew fatalities. Mig aircrafts comprised 56.7% of ai Loss of control of aircraft and collision with ground/water constituted 80.3% aircraft accidents pathologists and aviation accident-trained pathologists conducted 90.9% of autopsies. Histopa and toxicology provided useful information in 67.4% and 2.9% of cases. Pre-existing dis significance included coronary artery disease and pleuro-pulmonary tuberculosis. Recommenda have been made to overcome the present limitations in injury analysis and to provide better fligh

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Aviation demands close co-ordination of man and machine, and is exacting in nature. Accidents in aviation cannot be eliminated altogether. The aviation accident pathology gained a firm ground in establishing the exact cause of aircraft accident with the publication of report on Comet disaster in 1955[1].

The present study has been undertaken with the following aims :

a) To analyse and evaluate the autopsy findings and the fatal aircraft accident documents of the last 12 years period (1988 to 1999).

b) To compare the findings with that of earlier workers.

c) To make recommendations to overc present limitations and expand th of investigation.

Material and methods

A retrospective analyisis of fatal a accidents involving aircrafts of all th services of Armed Forces of India, occurred the period January 1988 to December 199 performed. The materials for the study com of fatalities involving aircrew utilizing respective medical report on major aircraft ac

* *Classified Specialist (Pathology) Inst Aerospace Medicine, IAF, Bangalore*

[IAFF (MS)-1956], findings of Court of Inquiry proceedings wherever available, gross autopsy report, histopathological findings, toxicological/biochemical data, and medical report from senior medical officer. Keeping in view the important role played by human factors in air crash, the following parameters were considered for this study:

a) Age of aircrew
b) Type of aircraft.
c) Phase of flight.
d) Relation of dead body with aircraft, after crash.
e) Autopsy details.
f) Histopathological and toxicological/biochemical data.
g) Mode/cause of death.
h) Pre-existing disease of likely significance.

Table 1 : Age distribution of aircrew fatalities

Age (years)	Fighter/Bomber/ Trainer pilot	Transport		Helicopter		Total	
		Pilot	Other aircrew incl. co-pilot	Pilot	Other aircrew incl. co-pilot	Pilot	Other aircrew incl. Co-pilot
21-25	49	-	7	3	4	52	11
26-30	35	-	4	3	8	38	12
31-35	14	4	2	6	10	24	12
36-40	9	-	1	3	-	12	1
41-45	3	2	7	-	2	5	9
46-50	1	1	3	-	-	2	3
51	2	1	3	-	-	3	3
Total	113	8	27	15	24	136	51

Results

One hundred eighty seven aircrew were killed in 127 air crash.

The age-wise distribution depicts 86.8% aircrew below 40 years of age (Table 1). The maximum number belongs to age group between 21-30 years (60.5%) wherein aircrews of fighter/bomber/trainer aircrafts appear to outnumber those of transport and helicopter aircrafts.

Analysis of aircraft types reveals that 81% of 127 air crash belong to fighter/bomber/trainer group (Table 2). Mig series constitute the majority (53.5% of all fatal air crash and 66% amongst fighter/bomber/trainer group). AN-32s aircraft and Cheetah helicopter distinctly outnumber the rest in their respective groups (Table 2).

Table 2
Aircraft types

Fighter/bomber/trainer	No. of aircraft
Jaguar	4
Mirage-2000	1
Mig-29	4
Mig-27	7
Mig-23	8
Mig-21	49
Hunter	4
Sea Harrier	2
Canberra	2
Kiran	8
Ajeet	2
HPT-32	7
HT-2	2
Iskara	3
Total	**103**
Transport	
IL-76	1
AN-32	5
AN-12	1
Avro	1
Total	**8**
Helicopter	
Mi 25	1
Mi-17	2
Mi-8	
Cheetha	9
Chetak	2
Sea King	1
Total	**16**

Phase of flight vis-a-vis aircraft typ depicted in Table 3. In flight phase compris majority of accidents (89%) mainly due to lo control of aircraft and collision with groun water surface. Mid-air collision involves 3 figh and 2 transport aircrafts.

Table 3 Phase of flight vis-a-vis aircraft types

Phase of Flight	Fighter/Bomber/ Trainer	Transport	Helicopter	Total
Take off	5	1	-	6 (4.7%)
Landing	7	1	-	8 (6.3%)
In-flight				
Loss of control	46	3	11	60 (47.2%)
Ground/Water collision	36	1	5	42 (33.1%)
Engine flame out	6	-	-	6 (4.7%)
Mid-air collision	3	2	-	5 (4.0%)
Total	**103**	**8**	**16**	**127 (100%)**

Table 4 : Relation of dead body with aircraft, after crash

Relation of dead body with aircraft after crash		Number of aircrew
1.	Impact	
	Retained	78
	Thrown clear	31
	Disintegrated	54
2.	Ejected	
	Ejection escape	17
	Spontaneous ejection	6
3.	Unassisted escape	1
	Total	187

Following air crash, majority of causalities remain with the wreckage of aircraft either as retained or disintegrated. The latter results mostly in supersonic and transonic jets (Table 4).

Majority of the autopsies (84.5%) have been conducted by service pathologists - not trained in aviation accident pathology (Table 5). This has lead to reassessment of the fingings later in correlation with related accident details, histopathological and toxicological/biochemical data.

Table 5 : Conduct of autopsy

Autopsy conducted by	Number of autopsies (%)
Aviation accident trained pathologist	12 (6.4)
Service pathologist	158 (84.5)
Other service doctors including Aviation Medicine specialist	3 (1.6)
Civil forensic expert	14 (7.5)
Total	**187 (100)**

The interval between aircraft accidents and the conduct of autopsy ranges from 4 hours to more than 2 months depending upon the accessibility of terrain and the retrieval of dead bodies. Majority have been conducted within a duration of 36 hours (92.3%) (Table 6).

Table 6 : Time interval between accident and conduct of autopsy

Time interval (hours)	Number of autopsies (%)
24 or less	85 (45.4)
25 - 36	69 (36.9)
37 - 48	13 (7.0)
≥ 49	20 (10.7)

Histopathological examination is found useful in defining the cause of death and pre-existing disease in 67.4% (Table 7). Differentation of antemortem from postmortem burns and occurrence of instantaneous death are the main aspects found useful in the histopathology in delineating causation/mode of death.

Table 7 : Usefulness of histopathologi[cal] examination

Usefulness of histopathology	Number of cases (
Useful	126 (6
Not useful	61 (3

Table 8 : Toxicological Biochemical analysis

Toxicological/Biochemical study	No. of cases	Positive	Negative
Carboxy Haemoglobin	120	3	117
Lactic Acid	36	-	36
Alcohol	45	-	45

Table 9 : Cause/mode of death in aircrew*

Cause/Mode of Death	Fighter/Bomber/Trainer	Transport	Helicopter	Total
Disintegration	56 (30.0)	6 (3.2)	2 (1.0)	64 (34
Multiple injuries	59 (31.5)	27 (14.4)	28 (15.0)	114 (6
Head and Spinal injury	10 (5.3)	1 (0.5)	9 (4.8)	20 (10
Burns	-	2 (1.0)	3 (1.6)	5 (2
Haemorrhage and Shock	6 (3.2)	2 (1.0)	7 (3.7)	15 (7
Others	-	-	2#(1.0)	2 (1

* Multiple factors caused death in some aircrew.

One died due to drowning and other possibly due to cardiac failure.

Toxicological/biochemical analysis has been performed to assess carboxy-hoemoglobin, lactic acid and alcohol levels in different tissue and/or blood samples. Table 8 shows significant positive findings have been found in 3/120 cases analysed for carboxy-haemoglobin. However, samples could not be analysed due to de[lay in] collection, poor preservation and putrefac[tion]

Multiple factors seem operated in cause/ mode of death (Table 9). Disintegration and multiple injuries are the most common cuases of death. Head and/spinal injuries are seen in fighter/ fighter-trainer and helicopter aircrew. A case each of drowning and possibly cardiac failure has been recorded. The latter has resulted in a co-pilot of helicopter which crashed while attempting forced landing and was found to have grade 3 coronary artery disease (CAD) in right coronary and grade 2 CAD in left coronary artery as per Mason's criteria [2]. The pilot of the fateful helicopter survived the accident.

Table 10 shows distribution of significant pre-existing disease in aircrew fatalities. Significant CAD is found in 4 cases while 1 case had unusal finding of pleuro-pulmonary tuberculosis on left side. It is conjectural to consider the possibility of causation of death due to cardiac arrhythmia in the former cases and compromised lung functions with increased ill-effects of hypoxia in the latter case.

Table 10 : Pre-existing disease of likely significance in fatalities

Pre-existing Disease	Age (yrs)	Aircrew Status	Aircraft type	Phase of flight
1. CAD (Gd II) Lt	41	Pilot	Hunter	In-flight (Engine flame out)
2. CAD (Gd II) Both	28	Pilot	Mig-21	In-flight (Ground impact)
3. Pleuro-pulmonary tuberculosis (Lt)	30	Pilot	Mig-21	In-flight (Mid-air collision)
4. CAD (Gd II) Both	31	Co-pilot	Chetak	In-flight (Ground impact)
5. CAD (Gd III-Rt) (Gd II-Lt)	42	Co-pilot	Chetak	In-flight (Loss of control and attempted forced landing)

Discussion

Human factors intend to outnumber other causes in aircraft accidents. High incidence of fatalities (60.5%) in younger aircrew (below 30 years) correlates well with large number of sorties being flown by them in supersonic or transonic jects. Earlier workers have reported incidence of fatalities as 56% [3] and 73% [4] in their respective study of 200 and 218 aircrash fatalities. In the present study, 6 aircrew were above 51 years of age as active flying is being continued by senior pilots in the fighter stream. In earlier studies, accidents have not recorded fatalities involving age group above 50 years [3, 4].

Amongst aircraft types, Migs of all types have shown a significant increase in fatal aircraft accidents, the incidence being 56.7% (68 out of total 120) and 66% (68 out of 103 fighter/bomber/trainer) aircrafts. The previous study of Mathur and Banerjee (1975-87) [4] have noted the respective figures as 30% 34/113) and 40% (34/85). However, this upward involvement of Migs in fatal aircraft accidents in the present study needs to be correlated with flying hours and serviceability-related issues of aircraft. These have not been within the purview of the present study.

Incidence rate of 11% during take off and landing phases of flight in the present study corresponds to the similar findings of Mason [5] and Adaval et al [3]. Mathur and Banerjee [4] have recorded 21% incidence of air crash in take off and landing phases of flight but have not specified any reason for such an increase during their period of study from 1975 to 1987.

The majority of aircrew have died due to impact of aircraft with ground or water. Deaths following ejection escape have resulted in 17 cases out of 113 fatalities observed in fighter/bomber/trainer group. The main reasons include difficulties in ejection, unsuccessful ejection, and early operation of BTRU followed by free fall etc. No similar data is available in earlier Indian series.

Majority of the autopsies have been performed by service pathologists - not trained in aviation pathology, leading to dealys in collation and interpretation of data to opine the cause of death. Similar observations have been made by earlier Indian workers [3,4].

Autopsy-accident interval has been more than 24 hours in 54.6% of fatalities. Previous studies have observed the incidence as 27% [3] and 56.5% [4]. Delay in autopsy examination does cause deterioration in morphological details of tissue samples due to putrefaction. A needs to be formulated to either mo prosector to the wreckage site or transp body remains for the early conduct of postm

Histopathology has provided information in majority (67.4%) of deaths been mentioned earlier. Delay in collect samples and their poor preservation have the role of toxicological/biochemical evalu accident.

Occurrence of asymptomatic prese disease in aviators especially CAD and pulmonary tuberculosis in the present stu emphasises the need to enforce stringent evalution during regular periodic examinations and pre-flight checks. Earlier have observed CAD [6-8] and focal myocard as pre-existing diseases leading post aircrash.

Conclusion and Recommendations

Aircrew flying fighter/bomber/trainer comprise the majority of fatalities. Of late, have been recorded in senior pilots (abo years) because of their continued fighter Increased involvement of Migs of all types aircraft accidents in the present study further evaluation in relation to flying ho serviceability-related issues of the ai aircrafts. No significant change from the been noted in the phase of flight when the took place. In spite of ejection escape, have resulted which can be reduced appropriate measures. Speedy autopsy exami by aviation accident trained pathologist w in better collection of samples and data com as well as collation, and thus increasing the of investigation. Early dispatch and preservation of samples for toxico biochemical tests will broaden their use in analysing more cases of air crash. Stringent medical measures will go a long way as flight safety means to detect the presence of pre-existing disease early and thus reduce the chances of exposing aircrew to likely risks of aviation.

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