An Analysis of Autopsy Investigations at IAM (1962-76)

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Abstract

Two hundred and seventy autopsy reports in respect of air crash fatalities for the period 1962–1976 have been studied with other relevant documents. Findings are correlated with factors like age of the deceased, aircraft types, phases of flight, survival, autopsy system, cause/mode of death and injuries to skeletal/visceral systems. Results are compared with findings of other workers in this field. Lacunae in the system of correlation of autopsy findings with crash factors are highlighted.

Introduction

Role of Aviation Accident Pathology in the investigation of fatal aircrash is firmly established and needs no further emphasis[2]. Aviation Pathology Cell came to exist in India in 1959 where autopsy material from all fatal aircrashes of IAF was centralised for investigation with a view to study the causes and modes of deaths, identify the medical causes of accidents and reconstruct the sequence of events.

Present study has been undertaken to evaluate the autopsy documents pertaining to the period 1962–1976 held in this cell, in a consolidated manner, ascertain their adequacy and suggest remedial measures for the shortcomings encountered.

Material and Methods

Material collected for the study comprised the following :

(i) Autopsy reports
(ii) Reports on histopathological examinations.
(iii) Reports on toxicological examination whenever undertaken.
(iv) Medical reports from SMOs where available.
(v) Court of inquiry proceedings.

Parameters chosen for correlation of autopsy findings keeping "The Man" as central theme, were as follows :

(i) Age
(ii) Aircraft
(iii) Phase of flight
(iv) Aircraft type and survival
(v) Relation of body with aircraft, after crash
(vi) Post-mortem examination
(vii) Accident-autopsy interval
(viii) Availability of body parts
(ix) Causes or modes of death
(x) Injuries
(xi) Histopathological examination
(xii) Toxicological investigations

Results and Discussion

275 deaths resulted from 183 aircraft accidents. 5 cases where autopsy reports could not be traced were left out of final analysis. Findings under the chosen parameters are discussed below :

(i) Age

Age of the fatalities was classified in broad groups and is shown in Table 1.

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TABLE 1

Age of Fatal Casualties

Age (years)	Pilot	Other Aircrew
21 — 30	160 (73.4%)	17
31 — 40	40 (18.3%)	7
41 — 50	3 (1.4%)	3
Unknown	15 (6.9%)	25
Total	218	52

Findings show that 73% of pilot casualties belonged to the age group of 21–30 yrs. Perhaps this high percentage is related to heavy flying at this age. However, this can be interpreted in totality only when age pattern vis-a-vis flying in the whole of Air Force is taken into consideration.

(ii) Aircraft accidents & Aircraft types

Due to their high speed, jet aircraft are likely to produce disintegration of the body more often. In Table 2 aircraft types and disintegration of bodies are given.

TABLE 2

Aircraft type & incidence of disintegration

Type of aircraft	No of deaths	Deaths due to disintegration
Supersonic and Trans-sonic	158	58 (36.7%)
Transport	86	16 (18.6%)
Helicopter	26	Nil
Total	270	74

In this series all the transport aircraft were non-jet type. Jet aircraft accidents have resulted in disintegration in 58 out of 158 deaths (36.7%) where as in transport aircraft deaths due to disintegration were in 16 cases out of 86 (18.6%). Fatal helicopter accidents involving 26 casualties did not result in disintegration of the body. In this respect our findings are consistent with that of Mason[7].

(ii) Phase of flight

Deaths occuring during various phases of fights are shown in Table No. 3.

TABLE 3

Deaths during various phases of flight

Phase of flight	No. of deaths	Percentage
Take off	22	8.4
Landing	13	5
Loss of control of aircraft	*88	33.4
Mid-air collisions	12	4.5
Collisions with ground or water	†115	43.7
Explosion, fire, break-up in air	13	5
Total	‡263	100

* In 88 cases it was opined by Courts of Inquiry that loss of control of aircraft caused the accident.

† In 115 cases where aircraf hit the ground or water, it was not possible to pin point the exact phase of flight, when the accident occured.

‡ 7 cases where particulars of flight were not known were excluded from this study.

Many workers are of the opinion that most of the fatalities occur during landing and take off. However, Mason[7] in his study of 158 fatalities found that only 11.5% of fatal accidents were referable to landing and take off phase. Findings of this report are in agreement with him.

(iv) Aircraft type and evidence of survival

Evidence of survival in relation to aircraft involved is mentioned in Table No. 4.

TABLE 4

Aircraft type and survival

Aircraft Type	In seconds	In minutes	In hours
Supersonic	1	0	2
Trans-sonic	6	1	4
Transport	2	0	2
Helicopter	0	0	0
Total	9	1	8

Evidence of survival was ascertained on the basis of circumstantial, clinical, autopsy, histopathological and toxicological evidence. Indication of survival was available in 18 cases out of 270 casual-

ties. 8 cases survived in terms of hours which include 3 cases of ejection escape, 1 case of spontaneous ejection on ground and two cases where body was thrown clear off the aircraft on impact. In case of helicopter accidents, deaths were instantaneous. Survival in terms of seconds was established only by histological examination of tissues.

(v) Relation of the body with aircraft after crash

Separation/entrapment in the aircraft, after crash modifies the injury pattern to a great extent. The entrapment may cause several types of secondary injuries making it difficult to evaluate the trauma on primary impact. In this study of 263 casualties it was found that 43 bodies had separated from the aircraft. This aspect assumes importance in injury analysis and reconstruction of events following an accident and is taken into consideration in subsequent discussions.

(vi) Post-mortem examination

Out of 270 fatalities, systemic examination was possible in 196 cases. Only 15 autopsies were conducted by Aviation Pathologists (7.6%). Rest of the autopsies were conducted by the pathologists who were not trained in the field of Aviation Pathology. In 15 cases where autopsies were conducted by pathologists trained in Aviation Pathology, useful information forthcame in 8 cases especially in respect of timing/sequence of injuries, survival and pilot-incapacitation.

(vii) Accident-autopsy interval

Expeditious conduct of autopsy is a pre-requisite for accurate results. As the accident autopsy interval depends upon the body retrieval we have classified this aspect into 2 phases viz accident-body removal interval and accident autopsy interval (Table-5).

TABLE 5

Accident-body retrieval/autopsy interval (Total cases 270)

Accident-body retrieval interval	No.	Percentage
More than 24 hrs	28	10%
Accident-autopsy interval	**No.**	**Percentage**
More than 24 hrs	74	27%

Table 5 shows that accident body removal interval was more than 24 hours in 28 cases (10%). This was more or less inescapable due to the difficult terrain where aircraft crashed. However, it is observed that in 74 cases (27%) the accident-autopsy interval was more than 24 hours. This reveals that in 46 cases though the body was retrieved before 24 hours, autopsy was not conducted during this period.

(viii) Availability of body parts

There is a general impression that aviation trauma is so extensive that the available human remains do not permit any systemic examination. In our study we have found that human remains were quite adequate for such studies in 196 cases out of a total of 270 (73%).

(ix) Causes or modes of death

In fatal aircraft accidents, the forces acting are much beyond the limits of human tolerance and result in soft tissue injuries, skeletal damage and injuries to the internal organs. These injuries are further modified if the occupant is trapped in the aircraft till all the stages of impact are over. If the body is trapped in the aircraft it mostly leads to disintegration whereas if separated during the impact, it rarely disintegrates. Burning and charring as a cause of death is also most likely when body does not separate. Causes of death under some crash situations are given in Table 6.

Overall assessment of this table reveals that disintegration occured only when body was retained. Multiple injuries account for most of the deaths irrespective of the fact whether the bodies were retained, thrown clear or ejected. Head injuries occured more often in retained cases, while the single death due to spinal injury occured when the pilot ejected. Deaths due to burns and asphyxia due to drowning occured more in retained cases for obvious reasons.

(x) Injuries sustained in aircraft accidents

In 74 bodies, where complete disintegration had occured, injury description was not possible. These cases were, therefore, excluded. Remaining 189 cases were considered under two main groups.

(i) Skeletal injuries

(ii) Injuries to the internal organs

(i) Skeletal injuries

Skeletal injuries encountered in 189 cases are classified in Table 7.

TABLE 6

Causes of death in crash situations

Cause of death	Impact		Spontaneous Ejection	Ejection escape	Unassisted escape	Total
	Retained in a/c	Thrown clear				
Disintegration	74 (33.7%)	—	—	—	—	74
Multiple injuries	123 (55.9%)	16 (84.1%)	1 (100%)	17 (77.2%)	1 (100%)	158
Head injury	14 (6.4%)	1 (6.3%)	—	3 (13.6%)	—	18
Spinal injury	—	—	—	1 (4.6%)	—	1
Burns	4 (1.8%)	1 (5.3%)	—	1 (4.6%)	—	6
Haemorrhage & Shock	2 (0.9%)	1 (5.3%)	—	—	—	3
Asphyxia due to drowning	3 (1.3%)	—	—	—	—	3
Total	220(100)	19(100)	1(100)	22(100)	1(100)	263

Note: 7 cases where particulars of flight were not known are excluded from this table.

TABLE 7

Skeletal injuries

Fractures	Impact		Spontaneous ejection	Ejection escape	Unassisted escape	Total
	Retained in a/c	Thrown clear				
Skull	90 (62%)	9 (47%)	—	18 (82%)	1	118
Facial Bones	81 (55%)	7 (36.8%)	—	17 (77%)	1	106
Spine	72 (49%)	6 (31.5%)	1	14 (64%)	1	94
Pelvis	52 (35%)	4 (21%)	—	13 (59%)	1	70
Sternum	30 (20%)	6 (31.5%)	—	4 (18%)	—	41
Ribs	122 (83%)	16 (84%)	1	16 (73%)	1	156
Arms	120 (82%)	14 (73.6%)	1	17 (77%)	1	153
Legs	120 (82%)	15 (79%)	—	17 (77%)	1	153

Note: Seven cases where relevant details were not documented are not considered in this table.

Skull was fractured in 118 cases (62%). Those bodies which were thrown clear from the aircraft on impact sustained fractures of skull in 47% cases only. An analysis of 153 cases by Mason [7] gives almost similar findings. Similarly facial bones, spine and pelvis sustained more fractures in retained cases as compared to those thrown clear. Fracture of sternum occured more often in separated bodies for which there is no satisfactory explanation. This, however, could be due to small number of cases recorded. In unsuccessful ejection escape, the injuries are much more marked because of the extreme force with which the bodies hit the ground. Fractures of ribs arms & legs occured with almost equal frequency in all the groups.

(ii) Injuries to Internal Organs

Injuries to internal organs are classified in Table No. 8.

TABLE 8

Internal Injuries Sustained in Fatal Aircraft Accidents

Injury	Impact		Spontaneous ejection	Ejection Escape	Unassisted Escape	Total
	Retained	Thrown clear				
Brain injury	108 (74%)	13 (68%)	—	16 (73%)	1	138
Heart injury	77 (53%)	11 (58%)	—	13 (59%)	1	102
Lung injury	127 (87%)	17 (89%)	—	16 (73%)	1	171
Lung (wide spread damage)	15 (10%)	1 (5%)	—	2 (9%)	1	19
Diaphragm	20 (14%)	2 (10%)	—	7 (32%)	—	29
Great vessels	4 (3%)	2 (10%)	—	6 (27%)	—	12
Stomach	20 (14%)	3 (15%)	—	3 (14%)	—	26
Intestine	33 (23%)	4 (21%)	—	4 (18%)	—	41
Kidneys	46 (31%)	6 (31%)	—	9 (40%)	—	61
Liver	90 (61%)	11 (58%)	—	17 (77%)	1	119
Liver (Extensive damage)	23 (16%)	2 (10%)	—	6 (27%)	—	31
Spleen	63 (43%)	7 (37%)	—	10 (45%)	1	81
Total	146	19	1	22	1	189

Note : Seven cases where relevant details were not documented are not considered in this table.

In separated and retained cases brain injury showed equal incidence. Though injuries to the lungs also showed almost equal incidence but wide spread damage was almost double in retained and unsuccessful ejection escape cases due to higher magnitude of forces as compared to those who were thrown clear from the aircraft during the crash impact. Tearing of marginal diaphragm has been reported by Hass[4]. In present series diaphragm injury was noted in 16% of cases, but those who had unsuccessful ejection escape showed 32% incidence thereby showing increased susceptibility of diaphragm to decelerative trauma. Heart and great vessels are liable to rupture when subjected to deceleration of high magnitude and in addition may receive penetrating injuries by broken ends of the ribs/sternum or by compression due to telescoping of cockpit structures. In present series incidence of trauma to heart is almost identical in all groups. Injury to aorta in 3% cases could be attributed to direct violence as the bodies were retained in the aircraft. However due to pure deceleration, as in ejection escape, the incidence increased to 27%.

Incidence of trauma to stomach is equal in separated and non-separated cases (14%). Stomach

rupture is rare in the absence of severe internal injuries. Intestine was injured in 22% cases. Mason[7] in his study of 158 cases found almost equal incidence of injuries to stomach and intestine though he quotes other workers to have found intestinal rupture more often. Kidneys were injured in 46 retained and 15 separated cases for obvious reasons. Hass[4] has found a very high incidence of liver injuries in aviation. Mason's overall figures are 48% in cases of crash accidents and 60% in separation type of casualties.[7] There is a general agreement that right lobe of liver is injured more often than the left. In the present study liver was injured in 61% of retained and 58% of separated cases. Extreme damage to liver, however, occured more often in ejection escape cases thereby showing more susceptibility to deceleration trauma.

(xi) Histopathological examination

Histopathological examination conducted on disintegration and non-disintegration type of casualties is shown in Table 9.

TABLE 9

Histopathological Examination

	Fatalities	Histopath Exam.	Significant Findings
Disintegration	74	73	16 (22%)
Non disintegration	196	176	134 (76%)

Findings indicate that in majority of cases histopathological examination was conducted and it yielded useful results in 22% of cases even when tissues were very scanty[3,6,7].

(xii) Toxicological Examination

Toxicological investigations were not undertaken in any of the disintegration type of casualties. In the other group, the investigation was done in 23 cases out of which in one case the cause of the death and accident could be established on toxicological report alone.[5] In large number of cases the specimens were found unsuitable due to poor preservation and delay in collection.

An attempt was made to correlate the injuries to skeletal system and viscera with crash factors, with a view to assess the role of safety equipment. The records of Courts of Inquiry, however, were not found adequate for such correlation.

Summary And Conclusion

The study shows that most of the casualties belonged to younger age group. Phase of flight in which most of the accidents caused death was loss of control and less often landing or take off. Most of autopsies were conducted by pathologists who were not trained in Aviation Accident Pathology. Where autopsies were conducted by trained Pathologists, the findings were distinctly more contributory. In 48 cases the autopsy was delayed beyond 24 hours even though the body was recovered earlier than 24 hours. In majority of cases availability of body parts was adequate to allow a systemic examination.

Injuries to skeletal system and viscera were modified according to the situation whether the body was retained in the aircraft or was thrown clear. Where the aircrew ejected, a different pattern of injury was found. It is interesting to note that even with variable factors operating in each aircraft accident, the statistical figures pertaining to injuries of lungs, aorta, liver and spleen etc show an identical pattern as compared to studies conducted in other countries. Correlation of these injuries with safety equipment could not be made for want of information.

Histopathological examination, irrespective of scantiness of tissue, has proved to be valuable. Toxicological examination though performed on a limited number of specimens has shown its usefulness. However, expeditious collection of samples and ideal preservation have not been possible in many instances.

Non-participation of a trained Pathologist (Aviation Accident Pathologist) in most of these accidents has led to a gross deficiency of vital information which otherwise would have been forthcoming had such a Pathologist been involved in the investigative machinery right from the beginning. Since no uniformity in collection of information/data is found in this series a lot of valuable data was either not available or had to be discarded from the study. A centralised scientific data compiling and information retrieval system will yield more fruitful results in future.

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