Assessment of Burns in Accident Fatalities

Wg Cdr SK Adaval*, Gp Capt GN Kunzru† and Major RN Verma†

Abstract

Records of 305 autopsies pertaining to aircraft accident fatalities have been reviewed at the Institute of Aviation Medicine, Bangalore to ascertain the incidence of burns in aircrash fatalities and to evaluate the investigative procedures available for differentiating between ante-mortem and post-mortem nature of burns.

It is observed that though burns were present in 125 cases (41%), their ante-mortem nature could be established in only 6 cases (2%). Various problems encountered in the diagnosis of ante-mortem burns in aircrew accident fatalities are highlighted and importance of detailed autopsy and toxicological examination is discussed.

Introduction

Most of the aircraft accidents are associated with fire.[1] Though in a large majority of cases fire is a post-crash complication, some of the accidents are caused as a result of inflight fire. Aircraft contains very highly inflammable material and therefore fires quickly attain severe intensity. The occupants of such aircraft, living or dead, thus get exposed to intense heat, sustaining burns and this effect is discernible on the human bodies in many ways. Due to vital physiological functions like circulation and respiration being intact in living human body, the effect of fire in such cases is different from that on the dead body. It would, therefore, be reasonable to expect a pathologist to be able to differentiate between ante-mortem and post-mortem burns by performing an autopsy examination on the human remains. It is emphasised by various workers that statistics on death from burning should be assessed only when an autopsy is performed. Stembridge and Moseley[6] suggest that many bodies incinerated after death have been classified erroneously as having died from burning, due to inadequate examination by an expert pathologist. Mosely[6] and Moseley et al[7] found burning the most frequent cause of aviation deaths after multiple injuries.

A thorough autopsy along with histological and toxicological examinations has been stressed by Mason,[4] which may bring out useful information in such problematic cases. Modi[5] lists line of redness, vesication and reparative processes as evidence of burns sustained during life. According to him, the redness occurs "immediately" after a burn and vesication forms within an hour. Evidence of infection and reparative processes is of late occurrence and is not of much importance in aircraft accident investigations. Anderson[1] emphasises that the earliest cytologic evidence of hyper thermal injury is a redistribution of fluid and solid components of the nuclei followed by nuclear swelling due to imbibation of fluid, rupture of nuclear membranes and pyknosis. Cytoplasm of the cells becomes first granular and later homogenously coagulated. Collagen loses its fibrillar character and becomes dense homogenous gel. The cells thermally denatured have a fall in pH and therefore develop increased affinity to basic stains.

* Classified Specialist in Pathology, Institute of Aviation Medicine, IAF, Bangalore 560 017.

† Senior Adviser in Pathology, ATNK&K Area and Officer i/c Aeromedical Research, Institute of Aviation Medicine, IAF, Bangalore - 560 017.

‡ Classified Specialist in Pathology, Military Hospital, Bhopal.

Material and Method

A restrospective study has been carried out on material pertaining to 305 autopsies conducted on aircrew between 1962-1978. Autopsy reports, histopathological examination reports and brief narratives of accident were perused. Burns were present in 125 fatalities and their corresponding histological slides were reviewed. An assessment was made, taking into consideration the criteria stressed by Mason[4] and data were defined accordingly.

Results

Table I shows the incidence of burns/incineration in 41 percent of aircrew fatalities. Ante-mortem burns could be proved in 6 cases. 5 cases are put in group of doubtful ante-mortem burns due to inadequate material available for examination. Two cases were classified in Group III due to burns immediately after death. 112 cases show the evidence of incineration after death.

Table I

Incidence and Type of Burns

Total Number of autopsies studied :		305	
Burns/Incineration present	:	125	(41%)

Group	*Type of Burns*	*No.*	*Percentage*
I	Ante-mortem burns	6	2
II	Doubtful ante-mortem burns	5	1.6
III	Burns immediately after death	2	0.65
VI	Post-mortem burns	112	36.75

Table II shows the findings as per Mason's criteria in Group I, II and III cases. In Group I, in addition to other findings, skin histology shows the evidence of tissue reactions. Carboxyhaemoglobin estimation of blood though done in only two cases is indicative of ante-mortem burns. Cases in Group II show only evidence of generalised congestion and oedema in the lungs but skin was not available for histology. Carboxyhaemoglobin level in the blood is done in only one case (Case No. 256), which is significant. Both cases of Group III show evidence of generalised congestion, oedema in the lungs and minimal vascular reaction in the skin.

Discussion

Incidence of deaths due to burning in aircraft accident fatalities: Death from burning has always been regarded as the most important hazard of aviation. In the Royal Air Force, Williams[13] found that 17.6 percent of all persons injured in aircraft accidents were incinerated. Williams[14] commented upon the relation of specific aircraft types to incineration of the occupants. Mosely et al[7] studied a series of cases and showed that 105 out of 1572 deaths (6.7%) were due to burning. A relatively high proportion of cases indicating ante-mortem burns arose from accidents to transport aircraft[9]. Fryer[2] has stressed importance of efficient rescue procedure as the key to survival from fire in transport aircraft accidents. In our series 41% of all air crash fatalities were incinerated. This percentage is very high as compared to that reported by Williams.[13] The reason could be that 68% of deaths in our series are from transport aircraft which contained larger number of passengers. A total of 6 deaths (2%) could be proved to be due to ante-mortem burns. Mason[3] found an overall incidence of 8.3 percent in his series. Five cases in Group II of our series could have been proved to be due to ante-mortem if skin histology was done or carboxyhaemoglobin estimation was conducted. All cases from Group I, II and III had multiple injuries with fractures of skull in 10 out of 13 cases.

Distinction between death from burning and post-mortem incineration: Table II shows Mason's criteria in differentiating ante-mortem burns from post-mortem incineration. The presence of froth at the nose and mouth is common to many forms of asphyxial death. It was present in 5 out of 11 cases of Group I and II. Mason[4] has encountered this in 7 out of 13 cases. Absence of froth may be due to its consumption in fire or premature cleaning. In our series most of the autopsies have not been carried out by the trained aviation pathologists and a possibility of missing this observation cannot be ruled out.

Widespread and obvious venous congestion is a universal finding which has also been found in all cases of Group I and II of our series. Absence of this may throw a considerable doubt on the diagnosis. In Mason's series, it was absent in only one case.

The absence of carbon deposition does not

TABLE II: FINDINGS AS PER MASON'S CRITERIA IN GROUP I, II AND III CASES

Group	Case No	Froth from nose & mouth	Macroscopic Venous Congestion	Carbon in trachea	Carbon in Oesophagus	Carbon in stomach	Microscopic congestion	Cerebral Vessels	Pulmonary Histology	Skin Histology	CO Hb %
1	2	3	4	5	6	7	8	9	10	11	12
I	1	No	Yes	No	No	No	Yes	Congested	Oedema	Tissue reaction present	Not done
	247	Yes	Yes	Yes	Yes	Yes	Yes	,,	,,	–do–	,,
	264	Yes	Yes	Yes	No	No	Yes	,,	Oedema + Carbon pigment	–do–	11
	266	Yes	Yes	Yes	Yes	No	Yes	,,	Oedema	–do–	Not done
	267	Yes	Yes	Yes	Yes	No	Yes	,,	,,	–do–	,,
	305	Yes	Yes	Yes	Yes	No	Yes	,,	Oedema + Carbon pignent	–do–	17.68
II	82	No	Yes	No	No	No	Yes	,,	Oedema	Not done	Not done
	108	No	Yes	No	No	No	Yes	,,	,,	,,	,,
	147	No	Yes	No	No	No	Yes	,,	Oedema + fatty embolism	,,	,,
	148	No	Yes	No	No	No	Yes	,,	Oedema	,,	,,
	256	*	Yes	Yes	No	No	Yes	Not studied	Oedema + †	,,	42
III	73	No	No	No	No	No	Yes	Congested + Fat Embolism	Oedema + Fat embolism	Mild congestion	Not done
	298	No	No	No	No	No	Yes	Congested	Oedema	Mind Inflammation	,,

* Not available for study

† denuded epithelium and carban particles

exclude a diagnosis of death from burning as a high intensity flash fire may leave no such evidence. Carbon particles were found in all cases in Group I except case No. 1, but were present in only one case of Group II. These particles were found in oesophagus in 4 out of 6 cases while they were absent in stomach from all cases of Group I and II. Mason[4] has also found lower incidence of carbon particles in stomach as compared to oesophagus.

Microscopic congestion of organs is also a universal finding which is more marked in spleen and brain. However, similar findings are also encounted in other forms of asphyxial deaths and cerebral decelerative trauma. This observation has, therefore, to be interpreted in the light of other evidence. Finding of intra-alveolar oedema with a moderate exudation of phagocytes are described in the lungs. Occasionally carbon pigments may be seen admixed with blood. In our series, pulmonary oedema was found in almost all cases of Group I, II and III but carbon pigment admixed with blood was found in only 2 cases of Group I and one case of Group II. Role of pulmonary fat embolism is controversial. Mason[1] did not find these emboli in any of his cases but in our series, they are positive in one case of Group II and one case of Group III.

American workers [9, 11, 12] have commented upon the value of blood or tissue carboxyhaemoglobin estimations in the diagnosis of death from burning. Glantz and colleagues[3] have accepted 10% saturation a significant level. It could be estimated in 2 cases of Group I and one case of Group II in our series. In all three cases, it showed significant levels. This is a very important diagnostic finding, but the absence of this observation does not exclude the diagnosis of death due to burning. On the other hand, false positive results may be obtained due to contamination of the cockpit air with carbon monoxide, with resulting incapacitation and post crash fire as happened in case No. 256.

Histological findings on the skin are very important from the diagnostic point of view but these findings may be obscured by the post-mortem charring and other artefacts induced by extreme heat. Anderson[1] emphasises that the earliest evidence of hyperthermic injury is functional rather than structural. Vascular reaction was present in all cases of Group I but skin histology could not be studied in all fatalities of Group II. In Group III, case No. 73 shows only mild congestion and case No. 298 shows only mild infiltration by inflammatory cells. In addition to this, the findings of venous congestion and oedema of lung, point to the diagnosis of burns probably immediately after death. However, in case of exposure to intense heat, the superficial vessels may become so rapidly fixed in a state of contraction that neither oedema nor hyperaemia is encountered. The reactive vascular changes would, therefore, be present at deeper levels. The fact that hyperaemic vessels after death regress to their normal state makes it almost impossible to utilise hyperaemia as a yardstick of ante-mortem reaction with any degree of certainity.

In reviewing all the six cases of Group I, it is seen that histological findings of skin supported by additional criteria as suggested by Mason[4] have helped in the diagnosis, though carboxyhaemoglobin estimation has been done in only 2 cases. In all the cases of Group II, with findings of generalised congestion, pulmonary histology and cerebral congestion, the diagnosis of ante-mortem burns could have been proved if supported by additional skin histology findings.

Conclusions

While many forensic pathologists are confronted with the problem of differentiating ante-mortem from post-mortem burns, the situation is somewhat different in aircraft accident investigations. If the aircrew are subjected to inflight fire and incapacitated, the aircraft is likely to crash within a few seconds. It is this interval of few seconds which is more important in our investigations. So far, there appears to be no established method for differentiating between ante mortem and post-mortem nature of burns when the duration between exposure to burns and death is only of a few seconds. Criteria described by Mason[4] have, therefore, to be interpreted in the light of total autopsy findings and circumstantial evidence.

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