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## Original Research Article

### **Retrospective Analysis of 1988 Indian Airlines 113-737 Crash at Ahmedabad: Medico-legal Investigation of a Mass Disaster**

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#### Abstract

**Introduction/Background/Aim:** This retrospective study of 1988 Ahmedabad airplane crash is aimed to determine the role of Forensic Medicine Expert in medico-legal investigation of a mass disaster. The larger aircraft, with capacity for more passengers, make such investigation a study in mass disaster planning, procedures and logistics. **Materials & Methods:** Medico-legal autopsy reports and accompanying police papers of victims of this airplane crash are evaluated and findings are compared with the studies having similar objectives. **Results:** Most of victims (84 %) were identified by the secondary methods of identification (Personal belongings especially metallic ornaments). 8% victims were identified by anthropological data obtained during autopsy e.g. age, sex, stature etc. Old scar and congenital deformities were useful in 4 % cases. Dental method was useful in 3 % cases and 1 case was identified by the lower limb prosthesis. Maximum number of deceased had burns (76.74 %), followed by head injury with skull fracture (54.26 %). Fractures of tibia and fibula are also seen in 42.63 % cases. Most common cause of death was burns (41.86 %), followed by multiple injuries to body (32.55 %). 15.50 % victims were died due to burns associated with multiple injuries. **Conclusions:** In airplane crash disasters, Forensic Medicine Expert has three major functions: identification of victims, documentation of their injuries and disease process, and correlation of these findings with the aircraft and crash site evidence. It is incumbent on individual expert as well as Forensic Medicine Department in their own and the public interest to have forward planning for such an eventuality.

#### 1. Introduction

Aviation is a highly skilled task that demands a perfect coordination of man and machine to complete the mission undertaken. 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.<sup>1</sup> On Wednesday 19<sup>th</sup> October 1988, the Indian Airlines flight IC 113 travelling from Mumbai to Ahmedabad crashed on its final approach to

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Ahmedabad airport. The crash site was 2.5 km away from the approach end of runway. The aircraft was a Boeing 737-200. In this air crash 124 passengers and 6 crew including pilot and co-pilot were found dead on the spot. Five passengers escaped with serious injuries, but 3 of them succumbed to the injuries later on in the hospital, 2 passengers survived.<sup>2</sup>

The court of inquiry arrived at the following conclusion: the cause of accident is error of judgment on the part of the Pilot-in-command as well as the Co-pilot associated with poor visibility.<sup>2</sup> 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) Bengaluru.<sup>1</sup>

Main objectives of the medico-legal investigation of an air craft accident is <sup>3,4,5,6,7,8</sup>

1. Identification of victims.
2. Establishment of the cause of death.
3. Identification of cause of crash (to look for the presence of intoxicants or evidence of disease in the pilot. Evidence of explosives or firearm's injuries)
4. Reconstruction of the event by study of the pattern of injuries.
5. Assessing effectiveness of safety equipments by identifying fatal injuries and thus indicating specific needs for improved safety features.

The prime aim of such investigation is to ascertain the conditions and causes of accident in view to safeguard the lives and prevention of accidents in future.<sup>8</sup> It is essential that Forensic Medicine Expert should ensure that, there is cooperative preplanning that includes adequate provision for collection, accommodation, examination and disposal of large number of dead victims. He is often the person with the most foresight and professional knowledge to acts as the stimulus and catalyst between the major agencies responsible for overall planning.<sup>6</sup> This study is aimed to determine the role of Forensic Medicine Expert in the investigation, assessment and evaluation of the fatal aircraft crashes. Study of such disasters provides many lessons in the organization of a major disaster.

This retrospective study is carried out with following aims and objectives:

- To study the various methods for establishment of identification of victims of aircraft crash disaster;
- To study the pattern of injuries and different types of causes of death in the victims of aircraft crash disaster which might help the investigating agency

in reconstruction of the disaster event and in establishment of cause of disaster by finding out any human factor responsible for the disaster either causative or contributory;

- To provide information that might prevent or minimize the occurrence and effects of similar types of incident or injury in the future, from safety point of view.

## 2. Materials & methods

Present study was conducted in Forensic Medicine & Toxicology Department of a medical college and tertiary care hospital in Ahmedabad city during the period of one year from January 2018 to December 2018. In this study, air crash disaster of Ahmedabad in 1988 was analyzed retrospectively in detail with respect to management of dead bodies and role of Forensic Medicine Experts in such disaster. Permission of Institutional Ethics Committee was obtained before starting this research project. For the purpose of this study only fatal cases involved in this disaster were included while living cases were excluded.

The data of 129 fatal cases was taken into consideration which was then compiled and analyzed for the present treatise. Information and data were collected from police papers including inquest reports, autopsy reports, and reports of laboratory investigations i.e. chemical analysis and histopathological examinations. Research papers of various authors regarding aircraft crash disasters and role of Forensic Medicine experts in such major catastrophic event were studied in detail and their work is compared with present study.

## 3. Results

Out of 129 deceased victims, 103 (79.84 %) were male and 26 (20.16 %) were female. Maximum number of victims were in the age group 21-30 years (28.01%), followed by 31-40 years (27.06%) and 41-50 years (24.8%) (**Table 1**). Most of victims (84 %) were identified by the secondary methods of identification (Visual recognition, Clothes and Personal belongings). Metallic jewellery, other metallic belongings like wrist watch and keys were proved to be very useful in the identification of the victims of Ahmedabad air crash disaster, especially in burnt and charred dead bodies (**Table 2**). Along with this, clothes (including pieces of collar with labels, undergarments), documents (air tickets, I-cards, visiting cards, driving license etc. found in the pockets or in the wallets), shoes, belt with metallic buckle, 'janeu' (sacred thread) were used in the

identification. So, preservation of these belongings during autopsy and their careful photography is very essential for the future identification. 8% victims were identified by anthropological data obtained during autopsy e.g. age, sex, stature etc. Old scar and congenital deformities were useful in 4 % cases. Dental method was useful in 3 % cases and only 1 case

was identified by the lower limb prosthesis. This emphasizes the role of complete autopsy in identification of burnt and mutilated dead bodies. Maximum number of deceased had burns (seen in 76.74 % cases), followed by head injury with skull fracture (seen in 54.26 % cases). Fractures of tibia and fibula are seen in 42.63 % cases (**Table 3**).

**Table 1: Age and sex wise distribution of victims**

Sr. No.	Age Group (Year)	Male		Female		Total	
		No.	Percentage	No.	Percentage	No.	Percentage
1.	0 - 10	4	3.1%	4	3.1%	5	6.2%
2.	11 – 20	1	0.77%	1	0.77%	2	1.54%
3.	21 – 30	23	17.83%	13	10.18%	36	28.01%
4.	31 – 40	30	23.26%	5	3.8%	35	27.06%
5.	41 – 50	30	23.26%	2	1.54%	32	24.8%
6.	51 – 60	14	10.85%	1	0.77%	15	11.62%
7.	>60	1	0.77%	0	0	1	0.77%
<b>Total</b>		<b>103</b>	<b>79.84%</b>	<b>26</b>	<b>20.16%</b>	<b>120</b>	<b>100%</b>

Most common cause of death was burns (41.86 %), followed by multiple injuries to the body (32.55 %). 15.50 % victims were died due to burns associated with multiple injuries. In 9.32 % cases isolated head injury was a cause of death and isolated abdominal injury was found as a cause of death in only 1 case (**Table 4**). In Ahmedabad air crash disaster, the cause of death in both pilot and co-pilot was burns.

**Table 2: Distribution of cases according to mode of identification**

S. No.	Mode of Identification	No. of Cases	Percentage
1	By facial recognition & Personal belongings	107	84 %
2	By old scar or congenital deformity	5	4 %
3	By prosthesis	1	1 %
4	Dental method	3	3 %
5	Anthropological data	13	8 %
6	Total	129	100 %

**Table 3: Distribution of cases according to body part injured (Multiple causes and overlap of injuries was a common finding in this study)**

S. No.	Injured body part	No. of Cases	Percentage	
1	Head injury with skull fracture	70	54.26%	
2	Lower limb fracture	Tibia & Fibula	55	42.63%
		Femur	29	22.48%
		Pelvis	4	3.1%
3	Upper limb fracture	31	24.03%	
4	Chest injury	43	33.33%	
5	Abdominal injury	29	22.48%	
6	burns	99	76.74%	

**Table 4: Distribution of cases according to cause of death (Multiple causes and overlap of injuries was a common finding in this study)**

S. No.	Cause of death	No. of Cases	Percentage
1	Burns	54	41.86 %
2	Multiple injuries	42	32.55%
3	Injuries+Burns	20	15.50 %
4	Head injury only	12	9.32%
5	Abdominal injury	1	0.77 %
6	Total	120	100%

#### 4. Discussion

A disaster such as an aircraft crash raises forensic problems that are both complex and unforeseeable because of the number of victims. In Ahmedabad aircraft crash disaster, serial numbers were given to each dead body at the site and brought to the mortuary of civil hospital, Ahmedabad. Complete post-mortem examinations were carried out in all the dead bodies and body parts by the team of Forensic Medicine Experts of B. J. Medical College, Ahmedabad. The identification of victims is essential from the humanitarian point of view so that families may be able to begin mourning, from legal point of view to establish the death certificate with or without a corpse and from the investigation point of view for the reconstruction process with legal and administrative investigations.<sup>3</sup>

Identification of victims of aircraft accidents is made difficult by the severe degree of injury and the accompanying conflagration. The task may be eased by the availability of an accurate passenger manifest. Identification of the pilot is a prerequisite to discovering a human cause for the accident, while an appraisal of safety factors is dependent on identification and accurate placing of the passengers within the vehicle.<sup>9</sup> In the medico-legal investigation of Airbus A-320 crash (France)<sup>3</sup>, identification criteria were divided in to preliminary criteria and conclusive criteria. The first consisted in the analysis of the personal belongings, the noticing of the sex, and the height. The conclusive criteria consisted of at least two specific morphological

characteristics such as birth marks, deformities, scar, prostheses, callus formation of old fractures, osteosynthesis material or in positive odontological identification in case of relevant coincidental features between premortem and postmortem dental records or in DNA identification by reverse paternity testing when the supplementary criteria were inaccessible.<sup>3</sup>

In Airbus A-320 disaster (France)<sup>3</sup>, out of the 87 victims 85 were identified by the forensic practitioners of the multidisciplinary team. In Ahmedabad Air Crash, most of the victims (84 %) were identified by the secondary methods of identification (Visual recognition, Clothes and Personal belongings). Metallic ornaments were found to be useful in the identification as they resist heat. Old scar and congenital deformities were useful in 4 % cases. Dental method was useful in 3 % cases and only 1 case was identified by the prosthesis. In 10 cases (8 %), dead bodies were identified by anthropological data obtained during autopsy e.g. age, sex, stature etc.

Metallic ornaments and other metallic belongings like wrist watch and keys had played important role in the identification of victims of Ahmedabad air crash. Characteristics of clothes (including pieces of clothes and undergarments) and documents i.e. air tickets, I-cards, driving license, visiting cards were also used for the identification. Shoes and belts with metallic buckle were also found useful for the identification. Prosthesis was detected in both lower limbs of one victim during autopsy by which he was positively identified. In three victims old scar of previous surgery was detected and subsequently they were identified by ante-mortem information given by the relatives. In two victims peculiar characteristics of toes (congenital deformities) were observed in the autopsy by which they were identified. In three victims, dental information was found useful. One of them was having golden metallic cap over the teeth and one had extracted teeth. In one child, dental profile (eruption state of temporary teeth) was used to determine age.

In Airbus A320 disaster (France), 9 victims could be recognized by morphological criteria only (for two victims, ante mortem fingerprints were found at home), 44 by morphological and dental identification, and 15 by odontological criteria only (for 81 victims, ante-mortem dental records were available) and finally 17 victims were identified through DNA typing.<sup>3</sup> The identification team required the association of Forensic Medicine Experts,

odontologists, radiologists and biologists. The result of their experience stresses two major points:<sup>3</sup>

1. First the necessity of performing the autopsies only after collecting the information given by the families.
2. Second the importance of DNA analyses when all conventional identification methods have failed.

In February 1998, a civilian airplane (**Airbus 300-600 R jet**) carrying 196 individuals crashed in **Taiwan** and killed another 6 people on the ground (combination of closed and open disaster). Although there were dental and medical records, fingerprints, photographic evidence and personal effects to recognize some of the victims, DNA analysis was needed for determination of identity of severely damaged remains. From the 202 people known to have perished in the plane crash, a total 685 fragments of human remains were subjected to DNA analysis. The same 16 DNA loci were utilized for testing blood samples from 201 relatives to determine parent/child and sibling relationships. With the exception of 19 victims identified by non-genetic evidence, 183 victims were successfully identified by DNA typing. In cases of severely damaged victims from a plane crash, DNA analysis proved to be the best choice to identify victims.<sup>10</sup>

The pattern of injuries sustained by the victims of aircraft accidents may give valuable clues that may aid the reconstruction of the sequence and circumstances of the accident. The 'typical' passenger carrying aircraft crash is likely to result in either a uniformity of injuries or a steady logical gradation of injuries. Study of the injury patterns may allow the investigation to compare different accidents. This is particularly important when the circumstances of an accident are unknown such as when an aircraft crashes in to the sea when there is no wreckage trail from which impact attitude may be deduced and when little or no aircraft wreckage may be available for engineering investigation.<sup>11</sup>

The majority of airplane accidents occur as planes are taking off and landing. Rutherford, in reviewing 473 civilian air crashes throughout the world, found that 34.9% occurred as the planes took off; 36.9% as they descended and landed; 26.4% in mid-flight and 1.8% while parked.<sup>7</sup>

Head injury is very common in aviation accidents and was seen in two thirds of Cullen's cases. In most of these the head injury caused or contributed to the cause of the death. A significant finding was that, the base alone was fractured in 18.9% of fatalities.<sup>11</sup>

Comparison of injuries sustained in different Air crash disaster is shown in **table 5**.

**Table 5: Comparison of various studies**

S. No.	Study	Type of Injury	
		Head Injury	Lower limb fractures
1	Ahmedabad Air Crash Present Study (129 victims)	53.33%	65.83%
2	Airbus A320 Crash <sup>3</sup> (France) (87 victims)	72%	92%
3	Cullen <sup>11</sup> (over land) 46 victims	91.3%	98 %
4	Cullen <sup>11</sup> (over sea) 10 victims	100%	100 %
5	Trident Air crash <sup>11</sup> 118 victims	67.8%	82 %

Fractures of shin are seen when legs flail forward and strike fixed structures or are trapped under seat in front of victims. Mason-1970 mentioned that this accident involved a piston engine aircraft that crashed in to a built up area while attempting to land at an airfield. The speed at impact was very low and the wreckage trail was short. A period of some ten minutes elapsed before the onset of a fire during which time many of the passengers were seen to be alive and conscious within the cabin. The hull of the aircraft remained substantially intact. Despite this 70 of the 81 passengers on board died of the fatalities, 35 had died of burning. The majority of these had impact injuries to their shins resulting in fractures that inevitably would have prevented their escaping the ensuing fire. While some victims did have head injuries caused by flailing over the lap belts and striking the seat in front, the majority did that examination of passengers seats revealed that the thin bar situated at the base of the seat back was deformed. The mechanism thought to be flailing upwards against the bar at the rear of seat in front of the victims.<sup>8,11</sup>

A Impact of this investigation was rectification of design of seat to avoid similar dangerous injuries in future.<sup>8,11</sup> Due to the abrupt deceleration, when an aircraft crashes, pilot's body is propelled in the direction of flights. Damage may occur in hands and feet if they are on the control at the moment of impact (Kreffft 1970). The force directed between the thumb and index finger during control column injury may be transmitted to the wrist & forearm. This may cause fracture or dislocation of the wrist. Stress applied to the forearm may cause fracture of the arm.<sup>8,11</sup> According to Cullen, injuries to the bones of thorax are the most common injuries seen and occur in 80 % of all accident victims.<sup>11</sup> In present study, chest injuries were seen in 33.33 % cases. In present study abdominal injuries were seen in 22.48 % cases. According to the Cullen<sup>11</sup>,

damage to the gastrointestinal track is, with one exception uncommon. They are often bruised. The distribution of bruising suggests that this is caused by compression of gut between a lap belt and the spine. This mechanism may also be responsible for the fenestration of the mesentery that often accompanies the bruising of the gut serosa. This injury is helpful in accident reconstruction as it demonstrates the use of seat belts. When such seat belt injuries are seen in cabin crew it indicates that they were seated if accident occurred at a time during the flight when one would not normally expect them to be seated, one may infer that the emergency was anticipated or that there was another reason such as turbulence for them to be seated.<sup>11</sup>

In the case presented by Rautji R. et al<sup>12</sup>, all occupants of the aircraft sustained severe deceleration injuries in the vertical axis i.e. from buttock upwards causing severe perineal tear and evisceration due to impaction of aircraft with the ground with substantial vertical speed.<sup>12</sup> In Ahmedabad Air Crash, most common cause of death was burns (43 %), followed by multiple injuries to the body (29 %). In 17 % cases, cause of death was combination of Polytrauma and burns. In 10 % cases isolated head injury was a cause of death and isolated abdominal injury was found as a cause of death in only 1 case. In airbus A320 crash of France<sup>3</sup>, the cause of death for all 85 (100%) identified victims have been attributed to multiple injuries and mutilations. In Ahmedabad air crash, both pilot in command and co-pilot were died due to burns. Multiple causes and overlap of injuries was a common finding in this study.

In Airbus A320 crash (France), 2 persons registered on boarding list were still missing it was not possible to find biological remains that could belong to these two passengers; they assumed their bodies had been almost completely consumed by the fire.<sup>3</sup> In addition to identifying the passengers' remains, the forensic pathologist will autopsy the flight crew in attempting to determine whether natural disease or drugs might have contributed to the accident, although, because of the size of the flight crew and the sophisticated instrumentation of commercial planes, this is highly unlikely. The forensic pathologist will search for trauma unrelated to the crash that might explain why the crash occurred. Thus, one will look for gunshot wounds and evidence of an explosion. Bodies may be X-rayed to look for bomb fragments.<sup>7</sup>

Mason et al (1963) reviewed 9 aircraft accidents attributed to coronary disease on the pilot; based on dual evidence of pathology and history, 4 of these accidents were considered almost certainly to have been so caused, 4 were very likely, and 1 was assessed as likely-it was considered impossible to be dogmatic. It clearly indicates importance of double crewing as a safety factor in passenger air travel.<sup>9</sup>

Whether in light or commercial plane crashes, the pilot (flight crew in commercial planes) should have a complete toxicology screen for the presence of alcohol, acid, basic and neutral drugs; alkaline drugs; narcotics; carbon monoxide and possibly marijuana.<sup>7</sup> In the Ahmedabad air crash disaster of 1988, most of the victims were identified by the secondary methods of identification. It is evident from this study that secondary methods of identification are ordinarily adequate to identify most of the dead bodies in a mass disaster situation. But, when dead bodies are severely mutilated or burnt and no any secondary identification data is available, then DNA profiling, Odontological examination and fingerprinting (Primary Methods) are the only methods which can be used for positive identification.<sup>13,14,15,16,17,18</sup> Doctor should be abreast with recent procedural norms, legal norms and medical records maintenance while dealing with disasters.

Ideally, all victims of aviation crashes should be autopsied. It is certainly necessary to autopsy the pilot and copilot for evidence of natural disease or toxicological issues that may have impaired their ability to fly the plane or even incapacitated them. It is important to autopsy aircraft passengers for three main reasons: to help with accident reconstruction, to help with the evaluation of safety equipment, and to help with the resolution of civil and criminal processes that may occur in the future.

### 5. Summary & Conclusions:

The role of Forensic Medicine Expert in a mass disaster event like aircraft crash can be summarized as follows.

1. At the disaster site, to locate, recognize, and recover human remains and other evidences, especially those impacted by disaster forces e.g. burned and mutilated remains.
2. Forensic Medicine Expert can play a vital role in the identification of the disaster victims. Identification of disaster victims is a complex and difficult task which requires the employment of

multidisciplinary teams that are well trained and managed.

3. It is highly recommended that in disasters like air crash or railway accidents, to rule out the human error factor (intoxication, sedation, and pathological condition), samples for chemical and histo-pathological analysis from the key victims must be taken.
4. Reconstruction of the disaster can be done by studying the pattern of injuries over the body of the victims. It is especially helpful in air crash disaster to know the position of the plane at the time of crash.
5. Establishment of the period of survival of the victims, which is deducible by studying the time since death is required in case of presumption of survivorship. Also it can be helpful to determine whether there was any lapse in the search and rescue operation, and accordingly from these findings, necessary corrective measures can be incorporated in the plan. Many victims of Ahmedabad air crash was having carbon soot particles in their respiratory tract suggestive of smoke inhalation. This finding suggest some period of survival after crash but due to fractures of bones of lower limbs and other injuries they could not have escaped.
6. Evaluation and analysis of the data during the course of medico-legal investigation of the disaster can be utilized as a tool for development and improvement of safety measures e.g. seat belts, air bags, head rests, helmets, leg guards, laminated windshields etc. They all were developed and improved over the years by studying such data and most of these safety measures have been made mandatory in many countries.

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