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Medico-Legal Investigations of the Airbus A320 Crash upon Mount Ste-Odile, France

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ABSTRACT: The authors present the medico-legal investigations and identification after the aircrash of the Airbus A320 upon the Mount Sainte-Odile (France). The identification team comprising investigators from the gendarmerie, forensic pathologists, odontologists, and scientists of the Institute from Legal Medecine rapidly retrieved and identified 85 of the 87 victims, with 17 being identified through DNA typing, three through fingerprints and the remaining through dental records and specific physical or X-ray findings.

Full autopsies were performed on all fatalities to determine patterns of injury and cause of death.

Results lead us to point out the importance of a multidisciplinary team of forensic practitioners especially trained for managing medico-legal investigation in mass disaster and the ability of DNA technology to solve complex identification problems.

KEYWORDS: pathology and biology, death investigation, mass disaster, victim identification, air disaster

The crash of the Airbus A320 upon Mount Ste-Odile took place on January 20, 1992 in the eastern region of France, close to the German border. This mountain, belonging to the Vosges range does not exceed 3400 feet in altitude.

The Airbus left Lyon airport for Strasbourg at 6:25 P.M. with 96 occupants, including the crew. Landing was expected at Strasbourg airport at 7:20 P.M. Due to bad weather conditions and heavy traffic, the plane was requested to delay its landing approach by

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flying over the mountains before coming back toward the runway. A few minutes later, the plane suddenly disappeared from the central tower radar; time was 7:30 P.M. Four hours later, the impact point was located at the site "La Bloss," a wooded area close to Mount Ste-Odile (2445 feet) and 30 km from the Strasbourg airport. Upon their arrival, the rescue squads found 87 fatalities and nine survivors sustaining injuries of various degrees. The aircraft was completely fragmented, with the cockpit and the tail apart; bodies were dispersed all around the wreckage. In addition, part of the destroyed fuselage had caught fire.

The medico-legal investigations were conducted by the team of the Strasbourg's legal medicine institute, including six pathologists, six odontologists, two radiologists, one serologist and one toxicologist with the help of the investigators of the French Gendarmerie.

The medico-legal procedure involved the following phases:

- Location of the victims, with charting, tagging and photographing;
- Gathering the bodies under a specific refrigerated tent at the same time;
- Distribution of a questionnaire to each family during the first 24 hours;
- Transportation to the Strasbourg Institute of Forensic Medicine;
- External examination, including identification of personal property and collection of fingerprints if possible;
- Full autopsy of all bodies and human remains, with odontological examination, tissue (muscle, bone and fluids, if any) sampling for DNA, and toxicological investigations;
- X-ray examinations only to confirm information reported by the family;
- Finally, return of the victims' remains to the families only after absolute identification.

All these medico-legal investigations had as main objectives the identification of the victims, the description of the patterns of injury on the victims, the identification of the cause of death of the victims, the detection of intoxicants in the victims (particularly in the bodies of the crew members) and the estimation of the time of death.

Material and Methods

Identification Criteria

The identification criteria were divided into preliminary criteria and conclusive criteria. The first consisted in the analysis of the personal belongings, the noticing of the sex, the height, hair, and eye color. The conclusive criteria consisted of at least two specific morphological characteristics such as birth marks, deformities, scars, prostheses, callus formation of old fractures, osteosynthesis material or in positive odontological identification in case of relevant coincidental features between ante- and postmortem dental records [*1*] or in DNA identification by reverse paternity testing when the other criteria were unavailable.

The autopsies were only performed after collection of the information from families in order to know which were the morphological characteristics useful for identification of the bodies by macroscopical or radiological examination.

Genetic Investigation

The genetic investigations, performed in the DNA identification laboratory of the Institute of Legal Medicine (H. Pfitzinger, manager), consisted in determining the genotype of each body or body part by genetic amplification of the HLA DQ alpha and D_1S_{80} loci in a first step. Second, RFLP probes were applied to the body of the victims who had not been identified by conventional morphological methods. The analyses were performed on samples of skeletal muscles and bone fragments taken during autopsy from each body or body part, stored at −20°C until analysis. The postmortem period of the samples varied from 36 to

240 hours, with an outdoor temperature at the spot of the crash of about −10°C. Tissue samples were well preserved and very little degradation was observed.

Blood samples were drawn from the family members of 19 victims (non identified by the morphological criteria).

The amplification step allowed us to attribute human fragments such as legs, arms or spine fragments to the corresponding body and permitted the selection of body fragments to be typed using the RFLP method. With this method, we looked for a possible family link between the parents or children of an unidentified victim. The analyses were performed on the tissue samples taken during autopsies and after extraction, the DNA samples were digested by Hinf 1 restriction enzyme; DNA profiles were obtained by using five single locus probes MS1, MS43A, MS8, MS31 and g3 (Cellmarks Diagnostic, UK) to explore highly polymorphic areas of the human genome.

After a visual interpretation indicating a possible match for a DNA profile of a victim and the profiles of the members of a family, the match was confirmed by computer-assisted image analysis (BioImage System, Millipore USA). Comparisons were performed between the RFLP pattern of each unidentified body and the profiles of the family members. This method provided a rapid and objective approach to visual evaluation. Our tolerance window was +/− 2.5% of the size of DNA fragments.

Results

Of the 87 victims, 85 were identified by the forensic practitioners of the multidisciplinary team. Nine victims could be recognized by morphological criteria only (for two victims, antemortem fingerprints were found at home), 44 by morphological and dental identification, 15 by odontological criteria only (for 81 victims, antemortem dental records were available) and finally 17 victims were identified through DNA typing. Using classical identification methods, 68 victims were identified within 2 weeks; the DNA reverse paternity testing took 10 more weeks (Fig. 1). The patterns of injuries on the victims and the distribution of injuries are shown in Tables 1 and 2.

The fragmentation of the bodies was due to the high speed of impact (350–400 km/h), leading to the widespread destruction of the aircraft and the passengers within. The fire that occurred after the crash contributed to more extensive destruction of the bodies, often

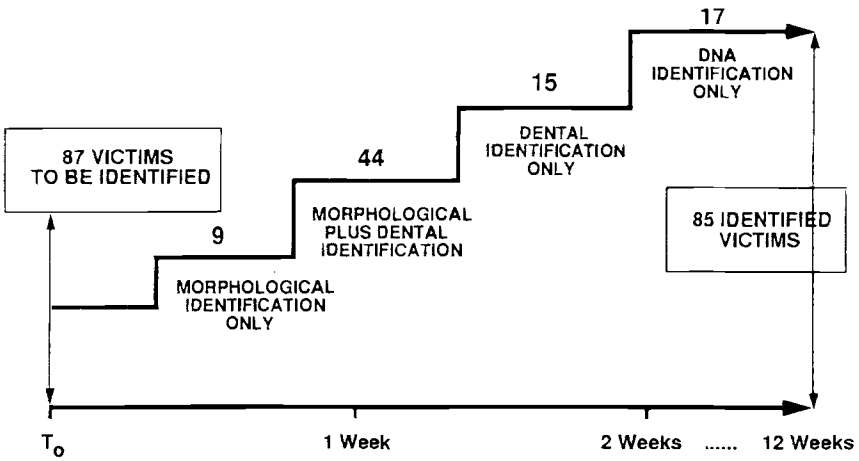

FIG. 1—*Identification steps and duration of the medico-legal investigations.*

TABLE 1—*Patterns of injuries of the victims.*

- Fragmented bodies: 60
- Incinerated bodies and burns: 27
- Severe head injuries (with multiple skull and upper facial bones fractures and evulsion of brain): 15
- Decapitation: 2
- Midtrunk section: 6
- Lowtrunk (including pelvis and coxo-femoral joints) sections: 6
- Amputations:
  - arms: 46
  - legs: 68

TABLE 2—*Distribution of injuries.*

Fracture of:	Laceration of:
Skull 72%	Brain 82%
Facial bones 71%	Lungs 75%
Cervical spine 8.2%	Heart 71%
Thoracic spine 40%	Liver 71%
Lumbar spine 7%	Spleen 80%
Ribs 91%	Kidneys 75%
Arms 70%	Stomach 30%
Legs 92%	

making conventional identification impossible. Thus, odontological examination and DNA fingerprinting may be the only methods available for making an absolute identification. Severe head injuries, including decapitation, were interpreted as the consequence of the impact of the head against the forward seat structures due to the sudden deceleration after flexion of the body over the seat belt. Mid trunk and low trunk sections were also caused by deceleration during which the body of the passenger in a forward-facing seat flailed about the seat belt before being ejected upward after the rupture of the lower part of the spine and dilaceration of the surrounding soft tissues. Amputations and fractures of the arms and legs also occurred during the decelerations by striking portions of the seat ahead and other parts of the aircraft structures. The distribution of injuries was similar to those published by other authors [*1*]. The question of the survivors versus fragmented victims was raised. The explanation could be found in the fact that these survivors were found in the tail of the aircraft, which showed much less injuries than the other parts of the aircraft.

The determination of the causes of the crash is still under administrative and legal investigations and actually not known. The possibility of an explosion before the crash was ruled out by the fire experts.

The toxicological analyses were restricted to the captain and copilot. Body fluids and tissues collected at the autopsy were negative for both drugs and alcohol. The causes of death for the 85 identified victims, have been attributed to multiple injuries and mutilations.

Incinerated bodies and burns have been considered the results of a post-crash fire. Twenty two fragmented bodies showed burn wounds or severe carbonization. At autopsy, no smoke inhalation or evidence of explosion were found.

For each body and human fragment, the alleles of the loci HLA DQ alpha and D1S80 were established and entered into a computer program in order to perform easy sorting of the data concerning on the one hand the bodies and on the other hand the fragments. In the few cases where body showed the same genotypes for the studied loci, we determined the sex by amplification of X and Y specific fragments and we then had to refer to the morphological description of the mutilated bodies to check if the given segment was missing.

All the unidentified victims were tested by the RFLP method to ensure that two of them did not match a given set of parentage results.

These analyses allowed us to proceed to the identification of 17 victims unidentified by conventional morphological methods. Two persons registered on the boarding list were still missing. It was not possible to find biological remains that could belong to these two passengers, we assumed that their bodies had been almost completely consumed by the fire. Typing by genetic amplification, combined with the search for parental links by reverse paternity allowed us to identify 17 victims not identified by conventional morphological methods. It was not possible to establish any formal biological trace of the two unidentified victims.

Discussion

A disaster such as an aircrash raises forensic problems that are both complex and unforeseeable because of the number of victims [*2,4,7,8*].

The identification of the victims is essential from the humanitarian point of view so that families may be able to begin mourning, from the legal point of view to establish the death certificate with or without a corpse, and from the investigators' point of view for the reconstruction process with legal and administrative investigations [*3*].

In this situation, the goals of the medico-legal team are to identify the victims and the cause of death, to report the patterns of injury, to look for the presence of intoxicants or evidence of explosives and/or firearm injuries and to determine the time of death.

Identification of bodies is complex after an aircrash and requires the contributions of perfected techniques and multidisciplinary teams involving forensic pathologists, odontologists, radiologists [*5*] and biologists [*6*].

It was essential not to hurry in any way, despite the pressures, and to seek effective and rapid cooperation from the families to guide investigations. Given these indications, descriptions and autopsies could be performed. In most cases, the victims had suffered an extremely violent frontal shock that had not been preceded by an explosion or a fire. The victims mainly showed signs of injury to the middle of the face, to the brain and skull, crushing of the ribs with dislocation of the spinal column and fractures or dislocations of both legs. Some bodies were dislocated because the safety belts did not tear when the aircraft crashed.

It was also possible to eliminate the theory of an explosion. The toxicological analyses were negative and, given the injuries sustained, most of the victims died instantaneously.

Sixty-eight victims could be identified with conventional morphological methods (odontological and anthropological identification) and 17 others could be identified by genetic investigations, mainly by reverse paternity looking for a possible family link between the parents or children of an unidentified victim.

Finally, every evening a meeting was organized so that all those involved in the identification process could compare the data gathered and the forensic findings with the information communicated by the families. Bodies were finally released only when the two sets of data concurred and only when the Director of the Forensic Medicine Institute coordinating the operations was satisfied as to the identity.

Conclusion

The success of the identification operations of the victims after an aircrash such as the crash of the Airbus A320 on Mount Sainte Odile (France 1/20/92) depends on the use of perfected techniques (recovery of the body, identification procedures, autopsies and sometimes biological investigations) as well as on a multidisciplinary team. The identification team required the association of pathologists, odontologists, radiologists and biologists.

The results of our experience stress two major points: first, the necessity of performing the autopsies only after collecting the information given by the families; and second, the importance of DNA analyses when all conventional identification methods have failed.

These identification procedures made it possible to identify 68 victims in two weeks and a further 17 were identified by genetic fingerprinting within the next 12 weeks. Finally, for only two victims, no biological sample could be found on the scene of the crash. These two victims could not be identified.

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