

The identification of the victims of the Linate air crash by DNA analysis

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Abstract. One hundred eighteen people were killed at Milan's Linate airport on October 8th, 2001 in a runway collision between a SAS airliner preparing for take-off and a private Cessna plane. The identification of the victims was carried out with visual, anthropological, odontological, and genetic means. The genetic identification was carried out through comparison of the remains with reference samples from personal objects of the victims or blood/saliva samples from their relatives. DNA typing alone led to the identification of 12 victims and 4 body parts, while DNA in combination with odontology allowed to identify 27 victims. The combined work of pathologists, odontologists and geneticists led to the positive identification of all 118 victims in 14 days. © 2003 Elsevier B.V. All rights reserved.

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1. Introduction

One hundred eighteen people lost their lives in the worst Italian civil aviation air crash in a collision between two planes on a heavy fog morning of October 18th, 2001.

One of the main concerns of the multidisciplinary identification team regarded the promptness of the identification procedure, in order to give burial to the victims as quickly as possible. The genetic tests allowed us to identify victims and body parts. The DNA team was composed of four forensic geneticists. Their work started upon conveyance of personal objects belonging to the victims or biological samples from their relatives or sibs. Both procedures were accompanied by signing specific forms, which were signed by the relatives/sibs conveying samples.

The DNA profiles obtained from the relatives or from the victims' personal objects were cross compared with those obtained from the victims' samples. DNA analyses allowed the identification of 43 victims, 39 of which were onboard the airliner or inside the baggage hangar hit by the plane, while 4 were onboard the Cessna plane. DNA

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analyses carried out in combination with odontological, visual and anthropological means allowed the identification of all of the 118 victims in 14 days.

2. Materials and methods

A total of 54 personal objects (15 analysed) and 57 saliva samples (32 analysed) had been conveyed to the Institute of Legal Medicine by the relatives of the victims. Two saliva and four blood samples had been conveyed by the Swedish Authorities. In one case, the Danish Authorities transmitted the genetic profiles obtained by the two daughters of a perished Danish couple. A total of 68 muscle samples had been taken from the victims' bodies (62 analysed) and from four body parts. PCI extraction was carried out in each case; standard PCR followed using the commercial kits SGM Plus™ and Powerplex 16™. Fragments were resolved on a ABI 373 with Genotyper automatic allele call. The derived profiles were stored in Excel tables. The profiles were confronted with one another side by side.

Statistical analyses with population-specific frequency data were carried out by calculating the likelihood ratio of paternity/maternity in motherless/fatherless cases, respectively, using a spreadsheet kindly provided by G. Carmody, Ottawa. No statistical calculations were made in case of direct comparison, being the matching probability in Caucasians $1:1.8 \exp 17$ (Powerplex), $1:3.3 \exp 12$ (SGM Plus). When low LR were achieved, no extra loci were analysed as no cross-match nor half-match (paternity/maternity relationships) had been observed among all the remaining samples. The likelihood of parenthood was calculated following the method suggested by Ballantyne [1].

3. Results

Muscle DNA: good results were always achieved except for one case. A second DNA extraction step was then necessary.

Reference samples: good results always except for three toothbrushes and one razor. In these cases, allelic drop-out or PCR failure was observed.

At the end of the identification procedure, 12 victims and 4 body parts were identified by DNA analysis only; DNA analysis in combination with forensic anthropology/odontology led to the identification of 27 victims.

Direct identification (victim-personal objects) was achieved in 11 cases, while indirect identification (mother/father–son/daughter or vice versa) led to the identification of 21 victims. Double identification (relatives and personal object) was achieved in several cases.

In four cases, the DNA identification of one victim allowed the identification of a relative or a sib of the identified victim.

4. Discussion

The team work of forensic pathologists, forensic odontologists and forensic geneticists led to a positive and relatively quick conclusion of the identification procedure of the 118 victims of the worst tragedy of the Italian civil aviation. “Traditional” identification methods (e.g. [2–4]) or completely genetic procedures [5–7] have been employed in cases of mass disaster. In fact the best approach has to be selected case by case, being each mass disaster to be regarded as unique [8]. In this case, some victims were still visually

identifiable, while others could be easily identified by cross-matching of ante-mortem and post-mortem dental X-rays, others only by DNA analysis due to complete carbonisation. It has been estimated that the odontological approach is not feasible in case of severe body fragmentation in approximately 20% cases [8] and genetic analyses could similarly be useless—even misleading—in case of non-paternity which could be revealed by the identification procedure itself. Therefore, in the present case, all available tools were employed, as suggested elsewhere [9]. DNA analysis was the only identification tool in 12 cases out of 118 (~ 10%). In other 5 cases, DNA tests results were conclusive due to incomplete odontological data, while in 27 cases (23%), genetic analyses reinforced the odontological identification. DNA analysis was then conclusive in 14.4% cases and it allowed the identification of body parts in four cases. Direct identification was achieved by comparing the victims' genetic profiles with their personal objects; indirect identification was obtained by comparing the victims' profiles with their relatives or their sibs in a paternity/maternity testing-like fashion. The good preservation of the victims' bodies along with reasonable/good amounts of DNA from the retrieved personal objects allowed to obtain reliable profiles; the typical artefacts, which can be observed in cases of low amount of DNA [10], have been observed only occasionally. No mutations in the father/mother-sib relationships were detected, although this could happen [11]. Likelihood ratios have been calculated only in case of mother/father-sibs scenarios: the obtained LR_s turned out to be highly significant in some cases, while in some other cases, they resulted in lower values. In the latter case, no extra DNA markers have been analysed both because of the purpose of the analysis (identification in a mass disaster case not in a forensic paternity/maternity setting) and because no cross-matches among the samples were observed. In case of direct identification, the identification power of the commercial kits employed was considered sufficiently informative. Following the described procedures, the identification of the victims of the Linate air crash of October 8th, 2001 was carried out in 14 days.

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