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The Gander Disaster: Dental Identification in a Military Tragedy*

ABSTRACT: The authors record the contributions of dentistry to the identification of victims of one of the most significant disasters in aviation and U.S. military history—the December 1985 crash of a DC-8 charter airliner near Gander, Newfoundland (now known as Newfoundland and Labrador), Canada, which killed 248 Army personnel and 8 crewmembers. Most of the dental records of the military victims were destroyed in the crash, and, as a result, this loss hampered dental identification. Nevertheless, dental identification was the primary means of identification for many because a very high percentage of the bodies were severely burned and fragmented. Many phases of the U.S. identification efforts have been reported, but the dental-investigation aspects have been mentioned only in passing. Therefore, this article documents the dental team's organization, methodology, and a variety of remarkable problems that the team encountered.

KEYWORDS: forensic science, forensic odontology, mass disasters, dental identification, Gander, Newfoundland

On December 12, 1985, Arrow Airways Flight 950, carrying 248 U.S. Army personnel from the 101st Airborne Division who were returning home from a six-month peacekeeping mission in the Sinai Desert and eight civilian flight-crew members, crashed on takeoff from Gander International Airport in Newfoundland (now known as Newfoundland and Labrador), Canada. No one survived. At the time, it was the worst aircraft accident in military history, the largest air disaster on record in Canada, and the fifth-worst disaster in aviation history (1–3). Also, at the time, more African-American military personnel died in the crash than in any other (4). Controversy has surrounded the exact cause of the accident from flight-crew error, to terrorist activity, to munitions on board (5). However, the consensus of the Canadian Aviation Safety Board concluded that the most probable cause was ice contamination of the wings (5).

Dental comparison was the principal means of identification because of incineration and/or dismemberment of the majority of the remains. Identification efforts were further hampered because the military members were carrying their medical and dental records, which were either destroyed or only gradually recovered during the ensuing two months due to inclement weather. In the aftermath, several articles documented many aspects of the accident investigation and efforts of the U.S. identification team. These reports examined the information obtained via air-photo analysis of the crash site (6), the problems associated with recovery and identification efforts (7), the planning and logistics of the identification processing center (1), the radiologic evaluation of the victims (8), and the role of anthropology (9). In addition, a significant number of articles examined the emotional effect on those involved—the human response to the disaster (10), the coping strategies of those who worked with the human remains (11), the impact on the health of disaster-family assistance workers (12), and other psychological aspects (13). However, missing from these comprehensive accounts is the participation of dentistry from the dentists' perspective, with the exception of articles on the computer-assisted postmortem identification (CAPMI) system, which the dental-identification team used for the first time (14,15).

Therefore, this paper chronicles the valuable role that dentistry played in the investigation and identification process of one of the most significant disasters in aviation and U.S. military history and records its historical significance. In preparation for this article, the authors reviewed, categorized, and tabulated data from the official Armed Forces Institute of Pathology (AFIP) forensic-dentistry after-action report and literature (1,8,16); relied on their firsthand experience as members of the AFIP dental-identification team; and considered only the organization, information procedures, victim processing, and problems that directly affected the dental team.

Response Team

An AFIP dental team was responsible for assisting in the identification of those killed in Gander after their arrival at the Dover Air Force Base (AFB) mortuary in Delaware. The AFIP Department of Oral Pathology was charged with providing forensic-dentistry support and leadership for this endeavor. At the time, the Department of Oral Pathology complemented the AFIP Department of Forensic Sciences with aerospace pathology, forensic pathology, and toxicology divisions. The chair of the Department of Oral Pathology was chief of the Forensic Dentistry Section for this disaster mission. The assembled U.S. dental-identification team consisted of 23 dental officers of the Air Force, Army, and Navy: ten were general dentists, nine oral pathologists, two oral surgeons; one was a prosthodontist, and another an endodontist. The dental support

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team consisted of 16 Air Force and Army enlisted personnel, most of whom were rated dental technicians with dental radiology expertise, and two computer specialists. Prior to the Gander disaster, the AFIP dental-ID team was a triservice endeavor only once before and that was for the crash of a TWA airliner (Flight 547) in Virginia.

Identification Data

Despite high winds and heavy snowfall at the crash site, the Canadian authorities did an excellent job of search and recovery; however, because of the inclement weather, the last bodies and remnants of dental and medical records were not recovered until nearly two months after the crash (7). The identification center in the mortuary at Dover AFB ultimately received 256 bodies or the remains thereof for processing and identification. Mulligan et al. (8) and Hinkes (9) have provided accounts of the various team interactions and means that the teams used to identify all 256 bodies. The dental team spent 70 days at the Dover AFB mortuary.

In-Processing of Remains

To standardize and facilitate the examination of the victims, the identification center was organized into ten "assembly line work stations" (1,8). Dentistry occupied two of the ten workstations—the Oral Surgery/Postmortem Dental Radiograph Section and the Postmortem Dental Examination and Charting Section (Table 1).

Identified Remains

Of the 256 bodies received at Dover AFB, approximately one-third were relatively intact, one-third were partially intact, and the remainder consisted of several hundred isolated body parts including teeth, jaw fragments, and portions of the craniofacial complex. Fragmentation and burns precluded visual recognition for identification in all but two of the victims (8). Most of the dental and medical records were destroyed in the crash, and, as a result, the Records Management Team had to contact previous duty stations, close relatives, civilian dental and medical facilities, and dental laboratories in an attempt to obtain any available antemortem records and/or radiographs. It procured antemortem dental records and/or dental radiographs on 179 members of the military and the eight crew members. In addition, 36 antemortem dental radiographs were eventually recovered at the crash site and were used for identification. Dental team members spent many hours trying to reconstruct burned and fragmented dental charts, but with very little reward. As far as the authors can determine, only eight dental charts were salvaged from the crash site and adequately restored. The methods used to identify the 256 victims were dental, fingerprint, medical radiology, pathology, anthropology, visual recognition, and personal effects. Dental comparison alone or in combination with modalities other than fingerprints was the means of positive identification for 113 (44%). Dental plus fingerprint comparison accounted for 67 (26%) victims. Therefore, dental means positively identified a total of 180 (70%) of the 256 victims (it was also supportive in an additional 16 or 6%). Fingerprint comparison alone or in combination with other nondental modalities was responsible for the identification of 51 (20%) of the victims. One or more of the following identified 17 (7%) victims: medical radiographs, medical/surgical history, anthropology, visual recognition, and personal effects (8). The exclusion matrix method, which included dental data among the criteria studied, identified the remaining eight victims (3%). Dental evidence supported the exclusion of seven victims for identification in the matrix.

TABLE 1—*Identification center processing scheme for the Gander disaster.**

1. In-processing and photography
2. Personal effects
3. Fingerprinting
4. Jaw resection and dental radiology
5. Full-body radiology
6. Dental examination and charting
7. Autopsy
8. Embalming
9. Body preparation
10. Casketing and shipping

* Modified from Clark MA, et al. (1).

Analysis of Investigation

All mass disasters have certain elements in common, but each has certain problems that make it unique. The Gander tragedy was certainly no exception with its special set of problems. The nature of the crash resulted in a high incidence of body fragmentation and loss of dental and medical records, which were scattered over a wide area of inhospitable terrain. That coupled with persistent heavy snowfalls made for an extremely difficult and prolonged search and recovery. The following briefly describes the dental methods used, the problems the forensic dental team encountered in the various components of the investigation, and the resultant recommendations and actions.

The Forensic Dentistry Section for the Gander disaster consisted of six component subsections to process more effectively dental evidence. The subsections were (1) Postmortem Jaw Resection, (2) Postmortem Dental Radiology, (3) Postmortem Dental Examination and Charting, (4) Antemortem Record Reconstruction, (5) CAPMI, and (6) Record Comparison and Identification. Each subsection had a senior dental officer as its team chief. In addition, a dental officer was designated as dental registrar for the duration of the investigation. A multiperson quality control system was used in all aspects of the dental-identification process in order to reduce errors and provide accurate documentation. Details of the verification techniques used by the AFIP dental-identification team have been previously described in detail (17,18).

Dental Registrar

For a disaster of this size, it was imperative to have a dental registrar whose sole function was administrative. The dental registrar had the following responsibilities: (1) maintaining a chain of custody for all dental evidence used in the identification process, (2) logging in and out all dental records from a secured central repository to all members of the dental-identification team and other authorized officials when appropriate, (3) inventorying all records received, (4) establishing and maintaining liaison with the nondental identification sections, (5) maintaining the current status of *all* identification efforts for all victims, and (6) establishing and maintaining liaison with the identification-center administration section when dental identification was achieved. With regards to Task 5, the dental registrar periodically had problems receiving timely identification-status updates on victims from the other disciplines. A large board posted in a central location displaying the identification status of each victim by each discipline would have been most helpful.

Postmortem Jaw Resection Subsection

Badly burned remains required jaw resection to facilitate oral radiology and examination. There were two surgical resection teams, each consisting of an oral surgeon and general dentist. The resection method (19), which allowed the mandible to remain attached to the victim, kept the body intact and eliminated the possibility of inadvertently commingling body parts. Many of the remains were frozen (1) due to the weather conditions at the crash site and subsequent cold storage and therefore had to be thawed before entering the forensic processing stations.

Postmortem Dental Radiology Subsection

The dental radiology team consisted of two dental radiology technicians per unit, working directly with a dental officer who was the quality assurance officer. Three dental radiology units provided optimal effectiveness. This design precluded delays with the dental radiology team. The addition of a dental radiology officer provided quality assurance for the exposing, developing, and mounting of the dental radiographs. If a radiograph did not pass the quality control, a new radiograph could be taken immediately and thus ensure that the victim departed the subsection with a superior set of postmortem radiographs. Both the postmortem examination and record comparison teams found this radiology protocol to be a tremendous asset. Locating the medical radiographic workstation between dental radiology and the postmortem dental examination workstation was ideal because it allowed processing time for dental radiographs (see Table 1). Now digital radiography capability in the forensic dentistry section of mass disaster operations has reduced or eliminated many of the dental radiology problems that were faced in Gander. Whenever possible, the dental-identification team took a full-mouth series of periapical radiographs. Periapical radiographs increased the chances for identification because they showed the entire tooth, its surrounding bony trabecular pattern, and bone loss from periodontal disease. For the first time the team used an automatic film processor on site. The efficiency of the dental radiology teams and the high-quality radiographs that they produced were directly responsible for the success of the dental-identification efforts.

Postmortem Dental Examination Subsection

The Postmortem Dental Examination Subsection had four teams of three dentists each or two dentists assisted by a dental technician. This organization of personnel permitted a thorough examination of all human remains for dental evidence, as well as an investigation of the body bag for fragmented dental structures. On several occasions dental fragments were beneath the body or commingled with other tissues and debris. However, despite the efforts of the postmortem dental team, this destruction and dispersion of dental evidence within the human-remains container at or after the time of body recovery sometimes deprived the team of essential dental information. The loss of evidence or lack of recovery of teeth was not a new experience; it had plagued the AFIP dental-identification team during the Jonestown identification operation (17). Wrapping the heads or securing the oral structures with ace bandages prior to placing the victim in the human-remains container would have in most instances eliminated the destruction and loss of the extremely fragile burned jaws and teeth.

Consultation activities were within the purview of the postmortem dental-identification team and most often involved medical radiology and anthropology. Interaction with the Medical Radiology Section was important because whole-body postmortem radiographs were valuable in screening for dental evidence that had been displaced to other parts of the body. The postmortem dental-identification team also provided dental-age estimations and reassociation of fragmented dental and/or jaw remains when anthropology consulted it.

Based on the lessons learned in Tenerife (20) and Jonestown (17), the dental-identification team was well aware of the potential for mental stress among team members and therefore had a predetermined plan to facilitate coping with psychological distress among members. It included daily in- and out-briefings on mental-stress issues. Nevertheless, varying degrees of psychological stress did occur among dental personnel, especially the young, inexperienced, enlisted workers. The dental leadership did not know how widespread the condition was since not all dental personnel revealed their feelings, and grief and distress are usually not observed on site (11), although one very dedicated young technician became overtly distressed on site. Conversely, an experienced senior dental assistant was reported to have had a severe case of post-traumatic stress syndrome (13). Since prolonged contact with large numbers of deceased can lead to emotional distress, members with forensic dental experience were teamed with the less experienced, and everyone frequently rotated among the subsections. During the Gander identification process, all dental-team members monitored all other dental-team members for signs of mental stress. As soon as one exhibited signs, the individual received on-site counseling. It was also recommended that such individuals receive follow-up care upon return to their home station. McCarroll et al. (11) conducted an informative study to determine the coping strategies of those who handled the bodies in three separate disasters, including Gander. Others have also reported on the psychological aspects of those who participated in the Gander identification operation (10,13); however, the emotional status of the dental team was not exclusively examined, so it is unknown how the dental team fared in comparison to other identification-team members. Benign humor and music can be an important tension reducer during mass-disaster operations, and these methods were used to good effect by the dental-identification team for the Gander disaster (11,16).

Antemortem Record Reconstruction

The production of the composite antemortem dental record is generally agreed to be the most demanding assignment in the dental identification operation. For this reason, a quiet undisturbed sequestered area with adequate lighting, table space, comfortable seating, and radiographic view boxes was absolutely essential. Because composite antemortem dental record reconstruction is perhaps the most difficult area of responsibility, the antemortem dental record reconstruction team included the most senior and experienced members available. They were coupled with those antemortem record reconstruction team members with less forensic experience. Although participation by the experienced staff ensured that the greatest degree of accuracy and completeness was possible, problems did occur. Nineteen (38%) of the first 50 composite antemortem dental forms had errors (16). This unsatisfactory transcribing was quickly remedied by the subsection team chief, who provided daily educational briefings and who thereafter performed random record reviews of the team members' charting (16). Team members took frequent rest periods to allay fatigue, and work periods lasted no longer than 12 h, which was very beneficial to the entire dental-identification team.

As mentioned, a serious setback to the dental identification of the military personnel was the destruction or loss of their dental records

in the crash. Unfortunately, the same problem occurred two years earlier in Beirut, Lebanon—the dental records were in the Marine headquarters building where the U.S. military members lived and where many died in the terrorist bombing (21). After that 1985 terrorist act, authorities apparently did not heed the recommendations of forensic dentists that dental records not be placed in harm's way. After the Gander mishap, a duplicate panoramic radiograph repository was established. The Gander dental-identification team had intact or portions of 223 antemortem military dental records; these consisted of dental charts and/or dental radiographs. However, many of the civilian records on the military personnel were not current since they were acquired from civilian dentists who had treated them prior to their entry into the service. A fortunate coincidence in this tragedy was that one of the dental-identification team members was an Army general dentist who had recently been stationed in the Sinai and had been the dentist for many who perished in the crash. Fortunately, he had kept a daily treatment log on every patient whom he had treated. This fortuitous decision was an invaluable source of antemortem dental information. His ability to recognize much of the dental work he had performed also gave us very useful information in the postmortem examination subsection. In addition, the antemortem dental record reconstruction team examined all available antemortem medical records for dental data.

CAPMI Subsection

This was the first disaster in which a forensic dental team used the CAPMI program. The standard antemortem and postmortem forms had been modified for their use with CAPMI. The CAPMI subsection consisted of the dentist who developed the CAPMI system for the U.S. Army Institute of Dental Research and two senior computer specialists. The CAPMI program expediently compared antemortem and postmortem dental evidence to produce a differential listing of possible dental identifications for each victim. This differential listing, generated on a computer printout, was subsequently submitted to the records comparison and identification subsection for definitive evaluation. There is no doubt that the use of computer analysis markedly facilitated the identification process in view of the large number of victims and the high incidence of dental and jaw fragmentation. As a result of the use of the CAPMI program in the Gander disaster, the program was further refined and modified. Albeit minor in comparison to the major contributions, the problems centered around the inability of the system to accept all of the data and computer codes to coincide with standard dental terminology. Lorton et al. addressed the CAPMI program and its subsequent improvements in 1988 (14) and 1989 (15), respectively.

Record Comparison and Identification Subsection

No more than six dentists, including the dental section team chief or his designee, were allowed in the record comparison and identification subsection at any one time. More than that was too disruptive. However, dentists from the other subsections could take turns rotating through this subsection. Members of this subsection were responsible for comparing all postmortem examination and radiographic findings with the completed composite antemortem records and radiographs. CAPMI computer-generated lists of the most likely matches helped expedite this phase of the operation. Subsection members ultimately manually compared antemortem and postmortem information. The subsection used an official identification summary form to summarize the identification data and to document the decision-making process. After the initial identification work-up by two subsection members, the chief of the forensic dentistry section or his designee would review all identification findings. The chief or designee and two dentists who were in agreement with the final interpretation signed the form. The degrees of certainty were (1) positive identification (certainty), (2) consistent with (possible), and (3) unidentified (insufficient evidence). One of the more interesting positive identifications that the dental team made was due to its comparison of a victim's palatal rugae with an antemortem dental cast of the maxilla, which is an acceptable method of identification (22).

The final eight identifications were developed by means of an exclusion matrix, which was possible, in part, because the remaining unidentified victims had available at least some positive and/or unique data. Identification by exclusion was predicated on knowing the names of all of the victims and procuring available anthropologic, dental, medical, and radiographic material on them (8). Each discipline in the investigation sought to discover contrasting characteristics between antemortem and postmortem data and thus to conclude with confidence that the data were from different individuals (8). The exclusionary components were dental, medical, medical radiology, and anthropologic data. Dental exclusions were based on comparisons of available antemortem dental records and radiographs to postmortem dental charts and radiographs. Combining exclusions by the aforementioned dental criteria with those of other disciplines proved to be essential in the identification of the last eight victims. Mulligan et al. (8) have provided a detailed analysis of all aspects of the exclusion matrix used in the Gander identifications.

Conclusions

The most significant obstacles to the successful dental identification of all U.S. Army personnel lost in this Arrow Airways aircraft accident were the loss of antemortem dental records—they included panograph radiographs—and the tremendous destruction of dental tissues. Within a 27-month span, the U.S. military had experienced two extraordinary incidents involving the destruction or the loss of dental records that were in close proximity to or with the military members at the time of their deaths. Therefore, the recommendations that the Gander dental-identification team made essentially reiterated the ones that the dental-identification team made following the Beirut tragedy: no permanent dental record and radiograph must ever accompany service members while they are in transit. Furthermore, each branch of the service should maintain dental records and radiographs for military members who are to be deployed to hostile areas separate or isolated from the members. Finally, the military should establish a central repository for the storage of duplicate dental records including duplicate panoramic radiographs on every military member, which it finally did April 1, 1986.

The destruction and postmortem loss of teeth and other oral hard and soft tissue hampered identification efforts at Gander as they did in the Jonestown (17) disaster. Therefore, the recovery team should make every effort to employ stringent measures to preserve dental remains during their recovery and transportation to the identification center. To optimize the preservation and collection of dental evidence at the disaster site, dentists should be members of the search-and-recovery team. This recommendation to use dentists on search and recovery teams is not new in forensic dental circles (17,23–25), but in our disaster experience authorities have seldom followed it.

Mental stress among dental team members is unavoidable even when measures are used to curtail it. The dental-identification team leader and dental-team members are the main source of support for

each other during the on-site operation. Because serious health sequelae can be associated with mental stress, the professional staff must be ever watchful so that they can institute appropriate health care measures when they are needed.

The performance of the CAPMI system validated the previous successful use of computers in mass-disaster dental-identification operations (17,26). The remarkable initial success of CAPMI helped promote the widespread use of computers in forensic dentistry and the birth of several comparable computer software programs that are in use today (27). By 1986, at least twelve computer systems had been developed worldwide (27).

The appointment of a triservice dental-identification team by the chair of the AFIP Department of Oral Pathology for the Gander disaster proved to be a success, and this triservice team concept is still in use today. It allowed the AFIP to maintain a recall roster that expanded its core of experienced personnel, reduced its response time, and thereby improved readiness.

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