THE DUTCH APPROACH IN DISASTER VICTIM IDENTIFICATION

L'APPROCHE NÉERLANDAISE DE L'IDENTIFICATION DES VICTIMES DE CATASTROPHES

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SUMMARY

A disaster is a 'sudden calamitous event that seriously disrupts the functioning of a community or society and causes human, material and economic or environmental losses that exceed the community's or society's ability to cope using its own resources'. Often disasters coincide with the loss of numerous lives. The recovery, identification and repatriation of the (remains of the) victims is vital to the mourning process of the relatives and is needed for legal clearing. All efforts made for this purpose are referred to as Disaster Victim Identification (DVI). Over the past decades, the Dutch DVI team has made several contributions to increase the efficiency of the internationally accepted Interpol DVI-procedures. This article presents, from a medical officer's point of view, the basics of a disaster victim identification response and discusses some of the recent methodological advances used by the Dutch DVI team.

KEYWORDS

Disaster Victim Identification, Mass Fatality Incident, Forensic Anthropology, Forensic Pathology, Interpol, DNA-analysis.

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RÉSUMÉ

Une catastrophe est 'un événement soudain et calamiteux qui perturbe gravement le fonctionnement d'une communauté ou d'une société et provoque des pertes humaines, matérielles et économiques ou environnementales qui dépassent la capacité de la communauté ou de la société à les surmonter à l'aide de ses propres ressources'. Souvent les catastrophes coïncident avec la perte de nombreuses vies. La recherche, l'identification et le rapatriement des (dépouilles des) victimes sont vitaux pour le processus de deuil des proches et nécessaires pour les formalités légales. Tout ce qui est fait dans ce but s'appelle DVI (Disaster Victim Identification – Identification des Victimes de Catastrophes). Ces dernières décennies, l'équipe DVI des Pays-Bas a fait plusieurs contributions à l'augmentation de l'efficacité des procédures DVI d'Interpol qui sont acceptées sur le plan international. Cet article présente, du point de vue de l'intervenant médical, les bases d'une intervention DVI et examine certains progrès méthodologiques récents utilisés par l'équipe DVI des Pays-Bas.

MOTS-CLÉS

Identification des victimes de catastrophes, Incident avec un grand nombre de victimes, Anthropologie médico-légale, Pathologie médico-légale, Interpol, Analyse d'ADN.

INTRODUCTION

A disaster is a 'sudden calamitous event that seriously disrupts the functioning of a community or society and causes human, material and economic or environmental losses that exceed the community's or society's ability to cope using its own resources' [1]. Although disasters are not defined by the type of injury or the death of their victims they often coincide with the loss of numerous lives. In such a case it is also referred to as a Mass Fatality Incident (MFI), an incident where 'the number of fatalities is greater than normal local arrangements can manage' [2]. Casualties may range from few to many thousands.
Some mass fatality incidents are due to natural causes, such as hurricanes, earthquakes or tsunamis. Others have non-natural causes such as from collapsed buildings, nuclear plant accidents, plane crashes, suicide bombings, shoot outs, etc. Increasing internationalization has made multinational involvement in case of both natural and non-natural disasters the rule rather than the exception. In some non-natural ones criminal intent adds judicial complications.
Of course, in every disaster, the assistance to survivors has priority. And always it is followed by the recovery, identification and repatriation of the (remains of the) victims, being vital to the mourning process of the relatives. At the same time the drawing up of a death certificate for every individual and/or the request for a criminal investigation is needed for legal clearing. Both require the identity of the deceased. This is recognized by all member countries of Interpol in their 1996 resolution on the management of MFIs [3].
All efforts that are made to this purpose are referred to as Disaster Victim Identification (DVI). The primary identification process is conducted by police officers,

medical doctors, forensic odontologists and DNA experts, but can only be successful if basic logistic, infrastructural and safety demands are met. Any DVI effort is therefore multidisciplinary by nature and requires a large number of organizations and institutions to work closely together.

Within the chaotic context of MFI scenes the need for a standardized approach is apparent. In order to facilitate these teams Interpol produced a Disaster Victim Identification guide with auxiliary forms and specialized software. They are regularly updated by the Interpol Standing Committee on Disaster Victim Identification, and are the only internationally recognized standards.

Over the past decades, the Dutch DVI team has made contributions to the Interpol procedures to increase their efficiency. This article presents, from a medical officer's point of view, the basics of a disaster victim identification response and discusses some of the recent methodological advances in the Dutch DVI team.

PRINCIPLES OF VICTIM IDENTIFICATION

Victim identification relies on the matching of *ante mortem* with *post mortem* personal features, so-called 'identifiers'. Since many identifiers lack sufficient specificity for an acceptable identification, Interpol distinguishes primary and secondary identifiers [4]. The three primary ones are the most reliable. At least one of them is required for a positive, i.e. accepted identification. Currently, they are a dermal friction ridge pattern match (fingerprint match), a DNA profile match and a dental status match. Secondary identifiers are all other personal features. These lack sufficient scientific proof of identity for an acceptable identification. Examples are medical/anatomical details, tattoos, personal properties found together with the remains, etc. Facial recognition is explicitly not used for identification as it is notoriously unreliable in a DVI context. A secondary identifier may give a lead and so help to speed up the identification process and/or they may corroborate other evidence of identification. Only in selected cases, when primary identifiers are unavailable, a combination of secondary identifiers may provide sufficient evidence of identity to be accepted.

Eventually the identification is dependent on the quality of the proof provided by the simultaneously executed *post* and *ante mortem* data collection process. The *post mortem* data acquisition consists of a detailed examination and DNA sampling of the bodies and body parts of the victims. *Ante mortem* data acquisition collects information on identifiers of the missing persons. Though of equal importance as *post mortem* data acquisition, the *ante mortem* process will only be discussed in brief. Since one cannot anticipate which data will produce the final identification, as much as possible information is collected.

THE 'QUICK-SCAN'

Although not specified by Interpol, the Dutch team prefers to precede the in-depth analysis of the recovered remains with a so-called 'quick scan'. Apart from abiding to safety measures, e.g. related to past (chemical) treatment of body bag contents (for instance by formaldehyde), the prime goal of the quick-scan is to swiftly survey the contents of all available body bags in order to get insight into the quantity of the analyses to be executed. In the quick-scan one records the nature of the bag contents: human/non-human, complete/incomplete individual(s), minimum number of individuals, degree of decomposition and/or combustion. Especially when the remains are severely comingled, fragmented, separated and/or burnt one not only needs all-round detailed anatomical/osteological knowledge, but also specific knowledge on sexual dimorphism, growth and ageing. For this reason, all medical officers in the Dutch DVI team also hold a degree in forensic anthropology. The results of the 'quick-scan' enable the DVI team to prioritize body bag handling. Bags with bodies that are probably 'easy' to identify can be given priority to speed up the entire process, permitting early repatriation to relatives.

In a recent DVI involvement, the quick-scan was extended by the CT-scanning of every body bag to have, in addition to the regular survey photograph, an extra 'database' of the bag contents. The CT-scan also showed to be useful to detect the presence and spatial position of implants (e.g. of pacemakers and prostheses) and dental elements amongst the comingled contents within the bag [5].

IN-DEPTH *POST MORTEM* ANALYSIS

After the quick-scan, every individual body or body part is given a unique serial number, a so-called PM-number, and will be subject to the in-depth *post mortem* analysis. The 'pink' *post mortem* forms of Interpol specify every step of the process and thus warrant uniformity. In addition they create an easy means of comparison with *ante mortem* data [6]. The *post mortem* analysis consists of dermal friction ridge analysis, personal property recording, physical examination, tissue sampling for DNA analysis and odontology. Depending on the situation, the analyses can be executed serially or simultaneously. Every step of the process is photographed to create an uninterrupted chain of evidence.

DERMAL FRICTION RIDGE ANALYSIS

Human dermal frictions ridges develop during the 10th week of gestation and mirror the papillary folds of the epidermis [7]. Since their formation is subject to genetic and epigenetic factors, they are considered to be unique and are thus an excellent means of identification [8]. Although generally known as fingerprints, dermal friction ridges are also present on palms, soles and toes. Preferably, their pattern is digitally recorded by scanning equipment. This allows for rapid matching with *ante mortem* data. If scanning equipment is unavailable, printing on paper with print powder will do perfectly.
In case desiccation of the skin hampers proper recording, the skin can be dipped shortly in hot water [9] or be subcutaneously injected with water. Peeled off skin may be 'printed' by folding it over one of the fingers of the investigator. If the epidermis is no longer present, then the papillary folds of the underlying dermis may produce a satisfactory image. In case muscle contraction causes the hand to clench, thereby hampering access to the skin, then bisecting the flexor tendons of the fingers on the inside of the lower arm will unfold the fist.

RECORDING OF PERSONAL PROPERTIES

Personal belongings such as wedding rings, watches or wallets, especially when found on a single body, may show to be useful secondary identifiers. They might speed up the search. All personal properties are cleaned, photographed and categorized in a standardized way. They are carefully kept for return to the relatives, since they have great emotional value.

PHYSICAL EXAMINATION

The external physical/anatomical examination of a body or body part includes a complete description of all features relevant for identification. Listed are the anatomical completeness, state of preservation, sex by means of (external) sex characteristics, assessed age at death, skin characteristics such as from the skin itself, its hair ('colour', morphology), its scars or piercings and/or tattoos. An in-depth description of facial features is also included, but this is generally of little value due to the nature of the incident.
Also mechanical traumas and pathological changes as from diseases are registered. Although a preceding quick-scan may have forecasted the presence of remains of multiple individuals within a single body bag, special attention is required if its contents are comingled, anatomically separated and/or seriously fragmented. To a certain degree one should take into consideration that separated parts potentially originate from different individuals, and should be treated as such. Study of skeleton parts with or without additional DNA-sampling usually leads the way to correct the origin of the fragments and eventually to the recombination of individuals [11].
Internal body inspection is only performed if there is an indication. In case of seriously mutilated bodies or body parts, an invasive inspection of internal sex organs will be necessary to verify the sex. Other reasons to perform a restricted dissection are conformation of the type of passed surgical interventions or the model, factory mark and verifiable serial number of an implantation such as from a pacemaker or prosthesis.
X-ray inspections are requested for age at death assessment of children and youngsters by examining skeletal development, status of epiphyseal disc closure of the long bones and/or the status of dental mineralization [12].

SAMPLING TISSUE FOR DNA

Possibilities for DNA profiling depend on the state of preservation of the remains. The International Society for Forensic Genetics (ISFG) advises to use blood samples, muscle tissue, bladder wall smears, cortical bone tissue or a dental element [13]. When the body is in advanced state of decomposition, sampling of soft tissue for DNA analysis is no longer an option. Then it is better to rely on bone tissue, preferably cortical bone from the weight bearing extremities [14].
It is strongly recommended to excise bone tissue from an intact part of an extremity that is still covered by intact skin. Bone tissue from the upper leg is preferred, since its robust muscular covering protects it against DNA contamination from outside, and against DNA-degrading due to extreme temperature fluctuations. Alternatives are bone samples from the lower leg, the arms and from the vertebral bodies. Dental elements are less used, since they are more prone to temperature fluctuations and laboratory preparation is more tedious and time consuming.
In the 2004 Tsunami, The Dutch team developed a standard operation procedure for DNA sample collection. The protocol combines common sense and existing theoretic knowledge to minimize the chance of DNA contamination whilst maximizing the chance of successful genotyping [15]. It uses only easily obtainable instruments and materials, such as a mix of water, bleach/chloride and detergent as 'DNA-cleaner fluid' to remove contaminants. Over the past years, the execution of the original protocol has seen some improvements.

Instead of an H-incision into the skin and muscle to get access to deeper positioned clean bone tissue, a U-shaped incision is made. After sample excision it saves time in closing the 'entry wound'. If the skin of the site of entry is still intact and the underlying soft tissue is well preserved, then bone sampling is preceded by the excision of a DNA muscle tissue sample. For DNA laboratories DNA is much easier and more rapidly to extract from soft tissue.
In the original protocol, after excision and prior to storage, the bone sample was rinsed with tap water, and subsequently rinsed in 100% ethanol to dehydrate its surface. Presently, the final dehydration step is preceded by two additional rinses: first a rinse with DNA cleaning fluid, then a rinse with clean tap water. The total amount of rinses thus accumulates to four (tap water, DNA cleaning fluid, clean tap water and 100% ethanol). This minimizes the chance that any DNA-cleaner fluid remains on the sample or contaminates the alcohol 100%. Stringent adherences to these steps have led to a virtual complete elimination of cross contamination in recent Dutch DVI efforts, even when confronted with suboptimal morgue labor conditions.
Due to current sensitive DNA analysis techniques, laboratories may produce adequate DNA profile from even very minute bone samples, weighing 1-2 grams or even less. One should keep in mind that with such small sized samples, manually processing under morgue conditions becomes a hard to overcome challenge and chances of DNA contamination rise substantially. This holds especially for fragmented and commingled human remains.
All excised material should be cooled as soon as possible, preferably keeping them refrigerated until further processing.

DNA GENOTYPING

DNA genotyping is performed in a specialized laboratory. The Dutch DVI team works in close collaboration with the Netherlands Forensic Institute (NFI). The NFI is a government-funded, yet independent institute that combines execution and development of all major forensic disciplines. As such, it has accumulated much experience in DNA analysis for identification purposes.
Forensic DNA analysis focuses on highly variable parts (loci) in the DNA molecule. These loci are so-called short-tandem repeats (STRs): short parts of DNA with a repetitive base-code. The number of repeats varies between persons. As a result, the length of STRs can be used to individualize the DNA-profile and to ascertain kinship between persons. The combination of a number of loci increases the specificity of the DNA profile. At this moment the standard analytical set contains fifteen different autosomal STR loci.
For the analysis of [CUT: the] DNA, the genetic material must be extracted from [CUT: the] human tissue. In case of soft tissues (e.g. buccal swabs or muscle tissue) this is technically a relatively less complicated process if compared to bone tissue processing, and so a DNA profile can usually be produced within 24 hours. In case of bone material, the tissue must be pulverized prior to further processing and extraction, which requires specialized equipment and is more time-consuming.
After extraction, the DNA is amplified by the polymerase chain reaction (PCR). Current PCR techniques are so extremely sensitive that even minute amounts of DNA (less than 0,1 nanogram) can be amplified. In practice, even very small or severely decomposed tissue samples may yield a satisfactory profile. This extreme sensitivity however, increases the risk of contamination.
DNA retrieval and amplification is a highly automated, protocolled process and is carried out under strict and contamination free laboratory circumstances. The conversion of the DNA analysis data into a digital DNA-profile is also partly automated. This diminishes the chance of human administrative errors, ensures process consistency and objectivity and saves time. Finally, the digital profile is loaded into specialized software for comparison with those of (an) ante mortem reference sample(s) (see below).

DENTAL ANALYSIS

Tooth tissue is the most durable human material. Teeth often remain available for identification, even after exposure to heat, trauma or after a long time lapse [16]. Individual morphological details combined with personal dental record data make a dental status a reliable primary identifier. Dental analysis has the advance of being rapid to execute and cost-effective [17, 18]. Though, probability calculation of uniqueness is not possible. Specific knowledge and the availability of a (mobile) X-ray apparatus is necessary. *Post mortem* radiographs, so-called 'bite wings' are made to document the status of (intact) dentitions.

QUALITY CONTROL

At the end of the *post mortem* analyses, the entire process and its auxiliary documents and samples are double checked by a special officer. This quality control will assure that any flaw is corrected for on the spot.

ANTE MORTEM DATA ACQUISITION

In the *ante mortem* data acquisition process, first priority is the compilation of a list of missing persons. The complexity thereof depends on whether one is dealing with an 'open' (e.g. a natural disaster) or 'closed' incident (e.g. an airplane crash). In contrast to an 'open incident', a 'closed incident' concerns a group of prior known missing persons. A combined 'open-closed disaster' may be an airplane crash in a public area. In any case, an *ante mortem* team immediately starts collecting all relevant particularities to match *ante mortem* with *post mortem* data of potentially missing victims. This includes interviewing relatives, assembling medical and dental information and collecting of reference samples for dermal friction ridge pattern and DNA analysis. Reference samples for dermal friction ridge patterns can be found on personal items such as glasses, door handles or CD-covers. DNA reference samples are preferably processed from buccal swabs of first degree relatives and from personal items of the missing person. If direct reference material is unavailable, material from second degree (grandparents, grandchildren) or even third degree relatives must be obtained. Interpol provides special 'yellow' *ante mortem* information sheets to ensure uniformity during *ante mortem* data acquisition. All data of a missing person is filed under an unique AM-file number.

RECONCILIATION

During the reconciliation process, the results of the *post* and *ante mortem* data are screened for matches. For dermal ridge patterns and secondary identifiers this is performed by police officers, whereas for the dental data forensic odontologists are available. The DNA matching and calculation of the probability of the correctness of the DNA match is done by specialists of the NFI. Hundreds of DNA profiles are to be compared, a process prone for error if done manually. The NFI, in collaboration with the Radboud University of Nijmegen, has designed software especially for the comparison of DNA profiles under DVI conditions (Bonaparte; www.bonaparte-dvi.com). It compares all *post mortem* DNA profiles, as well as the profiles of all the *ante mortem* reference samples with the related pedigree information. By combining the DNA information with Mendelian inheritance patterns it positions the *post mortem* profile in the correct pedigree, and calculates the evidential value of the (familial) DNA match. The evidential value is expressed as a likelihood-ratio. This is the ratio between the likelihood that the DNA-profile belongs to the missing person and the alternative hypothesis that the profile belongs to a nonrelated individual. The likelihood-ratio is used to calculated the probability of the identity of the victim via Bayesian statistics.

Dutch law, in accordance with the standards of the International Society for Forensic Genetics, requires a probability of identity of at least 99.99% to accept a DNA based identification [19].

IDENTIFICATION BOARD

All identification reports from the reconciliation office must be presented to the Identification Board. This board consists of DVI experts, legal officers, a coroner and liaison officers of the involved countries. They evaluate the provided evidence and decide whether the proposed identification can be accepted. If so, a death certificate is drawn up and the identified body or body parts can be repatriated to the relatives.

CONCLUSION

The identification of (body parts of) victims in a mass fatality incident is vital to the mourning process of relatives and to the clearing of legal issues. The basis of a DVI response accords to the Interpol DVI guide with its forms. Additions by the Dutch DVI team, such as a *post mortem* quick-scan, a protocol for DNA sampling and the use of specialized DNA software, have added to its effectiveness. The unique nature of a DVI response requires a pragmatic approach of many disciplines and a constant re-evaluation and refinement of the used methods. ■

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