CHAPTER 2: MEDICOLEGAL WORK IN MAJOR DISASTERS

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There is no justification from the medicolegal standpoint not to follow all scientific procedures for the recovery, transfer, identification, and final disposal of the remains of disaster fatalities. A select group of experts who are experienced in these procedures should oversee the process. However, in situations where experts are not available, the community physician should take leadership and make use of all available resources to carry out these tasks.

INTRODUCTION

The composition of a team to manage mass fatalities in disaster situations will vary from country to country, region to region, and from event to event, depending on many factors. Some of these factors are: the availability of qualified people who are physically able to do the work, the availability of essential materials and equipment, the response capacity of the affected country, the specific conditions at the disaster site, and how knowledgeable the decision-makers are about the policies governing management of mass fatalities.

The work of handling, identifying, and disposing of dead bodies is based on forensic sciences and requires a multidisciplinary team. It is important to emphasize the close association that should exist among the professionals who perform this work. However, it may be impossible to mobilize a qualified team so it is necessary for the acting physician to understand the most important principles of managing dead bodies, and, in the absence of medicolegal experts, to carry out these tasks to the best of his or her abilities.

Texts about forensic medicine and forensic anthropology or criminology will provide the necessary information for handling dead bodies. It is not our purpose to explain how to determine the cause of death or how a forensic anthropologist establishes the identity of a corpse. While such expertise is necessary to effectively deal with mass fatalities in emergency situations, it is the domain of specific sciences. Our main objective is to guide readers through the necessary steps to organize the agencies dealing with the complexities of an emergency, and to alert those involved in disaster preparedness about the important organizational and managerial aspects of managing mass fatalities.

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ORGANIZATION OF NECESSARY PERSONNEL

Organization and preparation of the team

As mentioned above, the composition of a team to manage mass fatalities in disaster situations will vary from country to country, region to region, and from event to event, depending on many factors and conditions. Some of the factors that affect the process are the availability of qualified people who are physically able to do the work, the availability of essential materials, the specific conditions at the disaster site, and how knowledgeable the decision-makers are about the policies governing the process.

Notwithstanding the variety of conditions, there are certain premises that should be followed so that the organization and preparation of work done by medicolegal specialists is successful. They can be summarized as follows:

- Ability to rapidly locate and mobilize the team;
- Minimal need for material resources;
- Adaptability to difficult working conditions;
- Support from local health services and other institutions;
- Rapid and effective information processing; and
- Unified command in cooperation with the other participants.

The essential planning tasks include: development of an emergency plan that describes the distinguishing characteristics of the region or area; taking preventive measures that are based on the risk and vulnerability studies made of a particular location; and actions that individuals must take depending on the situation.

The basic objective of the health services is to save as many lives as possible in a disaster, or at least to reduce to a minimum the possible injuries and illness associated with the conditions following an event. In medicolegal work, the objectives are different; they are to:

- Legally determine or pronounce *death*;
- *Recover* the remains of the dead;
- Establish *identity* of the dead;
- Estimate the *time of death*;
- *Determine* the cause of death;
- Explain the possible *circumstances* of death;
- Prepare the remains for final disposal; and
- Study the event to assist in *prevention* in the future.

Considering all of the above, there should be close cooperation among the professionals and experts that perform this work, or in the absence of a team, the acting physician should understand these basic principles of managing dead bodies to carry out these tasks to the best of his or her abilities.

Formation of the group and the warning plan

The composition of the medicolegal working group for managing mass fatalities in disaster situations varies according to the actual conditions and the human resources available at the disaster site. However, at a minimum there should be one specialist in forensic medicine on the team; ideally, he or she will have specific training in managing this type of disaster. Pathologists and teachers of anatomy from medical institutions, if available, can complement forensic medicine specialists on a team or, in their absence, can replace them. Surgeons, orthopedists, and support staff in these specialties may assist if conditions permit. Also important are mortuary personnel, gravediggers, or anyone with experience in routinely handling the dead.

Although generally a parallel group, the medicolegal working team will have an important relationship with firemen, criminologists, and police medical examiners, as well as with search and rescue personnel. While the latter generally look for survivors, it is not unusual for them to find dead bodies and remove them from the disaster site. Search and rescue personnel may not be prepared to handle situations where there is doubt about whether a subject is still alive, and the information they can provide to the medicolegal team in such cases is particularly valuable.

The warning phase of the plan should be developed considering available communications systems, but there must be alternatives assuming that there will be power failures or other malfunctions that prevent them from working. The person-to-person contact chain is the safest way to inform, locate, and summon personnel and should be included in the plan. Individuals in the contact chain might be missing, and it is necessary to go to the next person so that the chain is not broken. The plan must specify whom to contact in such a case. This should all be addressed during the planning stage and, if possible, it should be tested systematically during simulation exercises.

Risk and vulnerability studies

There are technical publications that give detailed information about risk and vulnerability, and it is essential for disaster workers to be aware of the main events or emergencies that are most likely to occur in their region. These include natural events such as storms, volcanic eruptions, earthquakes, floods, tidal waves, storm surges, avalanches, and landslides, to cite a few examples, as well as events caused by human activity such as traffic and aviation accidents, armed conflict, fire, building collapse, gas leaks, chemical spills, and nuclear disasters, among others. Precise knowledge of the vulnerabilities and risks of the region or zone enables effective preparation for emergencies that will require a medicolegal response.

A risk map of the region should be available that analyzes a variety of important factors, for example, wind direction in the case of gas leaks, possible evacuation zones when rivers are flooded, the safest buildings, sites that could be used for the placement of dead bodies, and the location of radioactive materials, to cite a few examples.

Technical preparation of personnel

Once the medicolegal team is formed, a technical preparedness plan should be developed using knowledge of the most common hazards in a region or territory and considering available resources (human and material). The plan should be based on the work objectives already defined for these emergencies, that is: diagnosis of death, recovery of human remains, identification, establishing time of death, causes and circumstances of death, and preparation of the remains for their final disposal. It is also important to address how to prevent similar events in the future. This plan should address the principle medicolegal problems that we would face in a specific type of disaster in a particular place.

Cooperation agreements

When facing a disaster we must also incorporate community resources, including scientists and professionals who have specific roles in the community. Nothing should be left to chance: all aspects of disaster response should be taken into account with well-planned and comprehensive cooperation agreements made before an emergency occurs.

Agreements should be made with the appropriate individuals or groups regarding the following:

- Necessary personnel;
- Work sites;
- Instruments, equipment, and other material;
- Transport and communications;
- Water, food, resting areas, and first aid stations;
- Refrigeration and preservation measures;
- Information management.

Thus, in anticipation of a disaster, we should consider potential temporary locations for medicolegal tasks, which in an emergency might include sites usually used for other purposes (for example, warehouses, sheds, farms, meat-packing plants, or sports fields). Arrangements should be made with specialists (surgeons, veterinarians, and biologists, among others) who have other occupations during normal times to support the work of managing mass fatalities. Provisions should also be made to coordinate water and food services, as well as waste collection and disposal. These important facets of handling dead bodies should be agreed on before a disaster strikes.

Other essential items that should be included in agreements with participating institutions and individuals are: transport and refrigeration; communications; availability of backup generators should the need arise and/or connection to the electrical system serving temporary shelters and work areas; and effective management of information about the event.

Exercises and simulations

One way to evaluate and perfect a disaster plan is to conduct simulations and exercises that are as close as possible to the theoretical plan conceived by specialists. This is particularly important given the number of teams and individuals who are involved in a disaster and the variety in their backgrounds.

Certain things can be tested during a disaster simulation, for example: the time required for carrying out the warning phase of the plan, the logical sequence of tasks, circumstances for transport of human remains, the capacity of a specific facility to receive bodies, and procedures for security and control of access. Most important is the knowledge and understanding shown by the principal actors, and the real potential for putting the plan into practice.

In addition to the plans themselves, the simulations and exercises should be well conceived and studied before executing them. An exercise that is improvised or superficially performed can result in errors of interpretation and a loss of confidence in correctly planned measures.

In general terms, we can use different classifications for the exercises:

- *Actions*, for example, the warning plan and collection of information;
- *Forces*, such as rescue personnel and public safety officers;
- *Measures*, such as transportation and communications;
- *Possible sites*, that is, appearance as well as location of temporary accommodations;
- *Totality of actions*, forces, measures, and possible locations.

After each exercise, the plans should be reviewed and adapted, correcting aspects that proved to be unworkable by substituting them with more feasible ones.

For medicolegal work, it is important to inspect sites that might be used in the event of a disaster with mass fatalities. Medicolegal institutions and morgues, many of which are located inside community hospitals, might not survive certain events because of structural damage to the facility. For this reason, it is not unusual to have to use sites for both the reception and storage of bodies, or to move all of the activities to these temporary locations and disregard existing morgues. Good planning will anticipate the preparation of such locations.

Simulations have shown inadequacies in plans for transporting dead bodies. For example, one plan for using buses was approached as if the buses were going to transport survivors, which would be unfeasible. Also, plans for vehicles to evacuate the injured were impractical given the condition of the patients and the urgency needed to transport them. These examples underscore the importance of conducting simulations in each site.

Many exercises are first made in theory, on paper. We should be aware of the costs involved in carrying out an actual comprehensive exercise. Such an exercise should only be undertaken when all of the activities outlined in the theoretical plan are very well defined. The plan must be adapted to the reality of specific locations and situations represented in risk and vulnerability maps.

Material needs

Once an event that causes a disaster occurs, immediately needed resources must be mobilized. These resources will be in direct relation to the type of event, its magnitude, its effects, and, logically, the response capacity of the affected region or country, which could affect requests for external help, including international assistance.

If there has been adequate preparation, the material needs following a natural disaster should be well identified. External assistance in the form of supplies or specialists may be necessary when the magnitude of an event and the high number of deaths overwhelm the capacity of local responders. Requests for this assistance must be made quickly, either directly to the national authorities or through national authorities to the international community. While the response may be rapid, it will always take longer than the affected population expects.

The type of event has a major influence on the ability to respond, particularly in terms of managing mass fatalities.

For example, in the case of a hurricane with strong winds but without flooding, it is likely that there will be few deaths and, typically, the storm will be short-lived. In the case of a hurricane that causes flooding and landslides, the number of deaths may increase significantly. Owing to weather conditions and the likely disruption of transportation routes, rescue of survivors and recovery of bodies could be very difficult.

In sudden-impact events such as earthquakes, the number of dead is likely to be very high from the outset. Telephone, water, gas, and electricity services may be abruptly interrupted, and short circuits and gas leaks may cause fires, increasing the number of victims. These factors can overwhelm the health services, particularly where there is physical collapse of health facilities and will affect autopsy rooms or sites designated in emergency plans as temporary morgues.

These considerations apply to each type of event and vary according to existing conditions at the time of a disaster. The situation of a specific region, that is, the level of development of local and national infrastructure, influences the response. It is not possible to propose a formula for response: actions must be assessed for each individual case.

Whether dead bodies are recovered early in the rescue process or, in extreme cases, have reached the stage of putrefaction by the time they are recovered, completely changes the nature of the medicolegal work. Other factors affecting this work include complicated searches for buried bodies, for example as a result of landslides or avalanches; cases when the integrity of the bodies is compromised and visual recognition is difficult, particularly as a result of fire or building collapse; or situations where it is very complex to reach the body, as in the case of earthquakes.

The materials needed to manage mass fatalities change with each scenario. There may be greater requirements when there are body fragments, oftentimes burned, as almost always happens in aviation accidents or even traffic accidents. Sometimes res-

cuers must dig for days to find bodies buried in avalanches or landslides. Whether the situation is complicated or classified as simple because all of the bodies are visible and well preserved (if the term "simple" can apply in a mass fatality incident), there are basic requirements. The majority of these are addressed in the following sections.

Transport

Transport is needed for the specialists and support personnel required to deal with the mass fatalities, as well as for moving body bags, stretchers, a basic complement of instruments, equipment, water, food, tents or other temporary shelter, and electrical generators, among other items.

Once dead bodies have been removed from the site, specialized or mortuary transport will be needed. In most major disasters the availability of specialized vehicles is quickly exhausted and has to be improvised or adapted to meet the demand. In many countries adaptation is a standard practice, but in some areas there are regulations prohibiting the use of certain types of vehicles to transport dead bodies. Negotiations should be made in advance with authorities to avoid problems in this regard.

When adapting vehicles to transport dead bodies, it is advisable to use trucks or vans, preferably closed, with floors that are either waterproof or covered with plastic. The bodies or remains should have already been packed in duly marked body bags or other containers. This is addressed in more detail in the section on transfer of bodies and body parts.

To the extent possible, cover any lettering or symbols, including license plates, that identify the companies or individuals who own the vehicles being used to carry human remains. This is to avoid, among other problems, possible prejudice or negative repercussions for the owners should pictures of the vehicles be taken by the press and distributed.

Vehicles must be thoroughly cleaned once transport is completed, or when refrigerated vehicles are no longer required. The responsible epidemiological or health authority should certify cleanliness of the vehicle before it is put back into routine use. This certification is particularly important for refrigerated vehicles or "Thermo" type containers that can be used for preserving human remains, a topic that we will return to later in this chapter. Certification, besides being a guarantee that the work has been done, serves as legal protection for businesses or other entities from possible claims related to their services, especially if the routine use of the vehicles is to transport food, medicines, or even flowers, among other items.

Using health service vehicles—specifically, ambulances—to transfer human remains from the site of the disaster is ill-advised, even though it is a common practice. Even worse is the transfer of individual bodies in a situation where there are mass fatalities. Using high speeds, sirens and other measures to gain right of way in traffic when carrying dead bodies is reprehensible: medical emergencies that save lives should never be confused with the urgency of medicolegal examination of the dead.

Rational use of resources takes on greater importance in emergency situations and is one of the reasons for using health service vehicles and ambulances only to trans-

fer the injured and ill. Even in the absence of injured survivors, as in the case of aviation accidents with no survivors, using ambulances to transport human remains cannot be justified. Trucks, pick-ups, and vans should be used to carry human remains. Once identified, the bodies should be transported in mortuary hearses that are specialized for this purpose.

Communications

Communications are vital in routine life and they become critical in disaster situations. Current technological advances in this field favor a variety of communications systems. Minimal communications measures must be available in an emergency situation: first, to learn as much as possible about what has happened in an emergency and, second, to maintain information about the emergency, particularly when there are risks of worsening conditions for the population and relief personnel on the ground, including forensic experts.

Any number of communications devices can be deemed necessary, but may prove to be inadequate to meet our needs. These include fixed or cellular telephones; the beeper or locator to mobilize necessary personnel; using radio, fax, e-mail, and the Internet with all of their possibilities to satisfy information needs; and, finally, satellites such as the Planet One system.

Communications measures allow us to know what has happened while allowing us to transmit timely information to people at risk and to survivors. Recovering basic data that will help in identification in mass fatality situations is possible in part because there are adequate communications, including between countries.

For medicolegal work, the first thing to find out is the number and, if possible, the identity of persons who might be the victims of a disaster. Using this information as a starting point, it is possible to activate the plans for managing dead bodies. The potential number of victims gives an idea of the resources to mobilize. It also gives an idea of how to find necessary information for identification, a priority in disaster situations.

Walkie-talkies are helpful when organizing work at a disaster site in large, open spaces, without fixed communications between points. Radios that do not require manual operation (hands-free communicators) are effective for maintaining permanent contact with personnel working at the disaster site. This is especially important when the number of victims is very high and rescue personnel have to cover a large area.

In areas where bodies are stored, examined, and identified, and in other places where medicolegal work is done, the availability of an effective communications network is essential.

Developments in computers, in particular the emergence of the Internet and electronic mail, make it possible to transmit large quantities of information—text as well as large format images—at a low cost using minimal telephone time. This has turned out to be an important advance for forensic practice. It is possible to use very modern communications methods with cellular phones connected to computers and to satellite services (such as Planet One) even when working in rural areas or in com-

plex scenarios. While very expensive at this time, we hope that these services will be accessible to all of us in the future.

When gathering information it is very important to have sufficient computers in a network to simultaneously develop two databases. One is based on information about presumed victims (ante-mortem data) obtained from official sources, from relatives, and others who are investigating missing persons. The second database is of the human remains undergoing examination and is generated with data from individual exams on bodies or body fragments (post-mortem data). A computer network, therefore, is highly desirable in disaster situations.

In the absence of a computer network, the classic system using cards with perforated edges ("key-sort" cards) is satisfactory. While the work will not be done as quickly, and continuous contact with other authorities will be lacking, the cards do make it possible to do the task in an organized manner with relative ease, regardless of the number of victims.

Protective clothing and equipment

Depending on the type of disaster and the working conditions where dead bodies are handled, it might be necessary to have clothing that is suited to special conditions. In general, however, clothing normally worn in operating or surgery theatres or autopsy rooms is adequate. Conventional work clothes may be suitable depending on the type of terrain at the work site.

Disposable clothing is available and is recommended for many situations. In other cases, traditional fabrics are preferable owing to their strength especially when lifting bodies. Closed, boot-style shoes are also recommended in these instances. Moving bodies is inevitable in most cases, and even though there will be assistants, wearing back-support belts can reduce the chance of injury. Rain gear is also useful in case of storms.

In general, although the use of face masks is recommended in certain texts, we rarely consider them to be necessary. Since masks limit ventilation and the workers tire more easily, using them can slow down the tasks of moving, storing, and preparing corpses. It should be noted that the mask does not filter or provide protection over a reasonable period of time. Generally, there is no danger of contamination through the respiratory tract since there is no respiratory function in dead bodies and they do not present a danger for those handling them. Gases and strong odors are the most disturbing aspect.

Concerns during autopsy include the suspicion or possibility that a victim is positive for HIV, tuberculosis, or any of the known infectious illnesses mentioned in Chapter 3. In mass fatality situations, however, the possibility is generally minimal in relation to the number of victims. Standard hygiene and epidemiologic protective measures should be used, since we begin with the assumption that an undiagnosed or untreated illness might exist.

There has been much speculation about what should be done during autopsy when there is suspicion of HIV, tuberculosis, or other infectious disease in victims. It is only necessary to cover the mouth and nose when electric saws are used to open the skull, since the resulting bone particles, blood, and other fluids can stay in the air and be inhaled, even at a distance, by people in the morgue or in closed rooms where the operation is being done. There is also a risk for inhalation in open places depending on the direction of the wind and the position of the subject during the procedure. An effective protective method is to apply a constant stream of water over the incision area while the cut is being made, thus preventing the bone particles from becoming airborne and being inhaled. The same procedure done with a manual saw will not result in the same amount of pulverization and spattering because of the slower speed of the saw.

For the reasons mentioned above, it is not necessary to take extreme measures or use face masks throughout the handling of human remains. It is sufficient to cover the mouth and nose when necessary. In cases of autopsy, it is recommended that:

- Only the personnel who perform or assist in the procedure should be in the autopsy room or work site;
- A stream of water should be used over an incision area while a cut is being made;
- The opening should be made with a manual rather than an electric saw;
- The skull should not be opened if it is not a determining factor in death;
- *Body fluids should be neutralized with special disinfectants such as hypochlorite.*

It should be pointed out, however, that in certain types of disasters the use of breathing filters or gas masks is not only advisable but essential. This is the case when toxic gases exist at the site of the event and there is a potential escape of poisonous fumes such as in fires that generate toxic smoke, among others.

In a case where there has been a toxic gas leak —for example, ammonia— corpse removal will take place once the situation is under control. It should be kept in mind that gas may be trapped in areas that remained closed after the initial evacuation. Rescue personnel can be poisoned by inhaling gas while searching for bodies in these areas. Both rescue personnel and people returning to their homes after having been evacuated should be warned about this potential hazard.

Surgical caps, while not essential, are recommended for work in autopsy rooms. They are not necessary during the removal of human remains. Depending on the circumstances it is advisable to wear hardhats or some sort of protection against falling objects or a blow to the head during the recovery of corpses at the disaster site. When working in the field where there are steep slopes, a rock or other object falling from

a high elevation can reach high speeds and cause a land or rockslide that could seriously injure people working at lower levels.

The medicolegal team, like those working in search and rescue, should use clothing and shoes that are appropriate to difficult and varied working conditions. Depending on the situation, they also should carry equipment such as flashlights (laser flashlights are very popular); belts or vests with reflective material or with battery-operated light bulbs; sound devices such as whistles or megaphones with integrated sirens; canteens or other portable water receptacles; rope; knives; canvas or leather gloves; hand-held radios; and directional devices such as compasses, or even GPS and distance meters, among other items, that facilitate difficult work. In some cases radiation detectors or other sensors may be necessary, and in very cold climates workers will need coats or blankets (even electric blankets) and other accessories depending on the working conditions.

Instruments and equipment

This section addresses in general terms the instruments, equipment, and different technical procedures that might be necessary for managing mass fatalities in disaster situations. Some have been mentioned in preceding sections on transportation, communications, and clothing.

Rescue teams, whether firefighters, military, or civil defense workers, should have certain basic equipment. This includes equipment for tracking, debris removal, cutting, compression or decompression, fire extinguishing, illumination, and other basic activities linked to the work of search and recovery.

The teams should also have stretchers that can fold and are as light as possible, since bodies are often recovered in uneven terrain where it is impossible to use wheeled gurneys. Gurneys can be placed at intermediate receiving points where the ground is level, and can even replace typical work tables.

In disaster situations where there are massive fatalities, it is not an ethical violation to place human bodies individually on the ground, in an organized and respectful manner. This should be done only when the usual sites for holding the bodies are exhausted. In such circumstances there are basic rules: for example, it is prohibited to pile bodies one on top of the other in any storage situation. However, it is permissible to place bodies on top of others when transferring them from one point to another in available vehicles, or in extreme situations when it is necessary to use refrigeration to preserve the bodies.

Autopsy is not systematically performed in disaster situations but is reserved for those cases in which important information can be obtained both for clarification about the event and for victim identification. In cases where victims are well-known or it is advisable for other reasons, this scientifically important investigation should be carried out not only for clarification of the event but to determine other aspects relating to their death.

As part of emergency preparedness it is necessary to consider the requirements for autopsy, including basic autopsy instruments. The ideal instruments for autopsy include: scalpels with handles, different types of forceps and clamps, rib cutters,

knives, skull chisels, probes, hammers, manual and electric saws, ladles, magnifying glasses, scales, and tags, among others. A tape measure, ruler, or anything for measuring the body length and specific measurements such as the feet, are essential for identification, as well as a straight measure for photographic and film documentation. Basic facilities include tables, running water, and lighting.

The best option is to conduct autopsy in a morgue and by qualified personnel, but the situation may arise when a physician will have to carry out a autopsy with what is at hand. Experience shows that with great creativity and skill, it is possible to accomplish exterior and interior studies of a body using no more than a common kitchen knife.

Materials needed to collect biological samples (for toxicological, histopathological, microbiological, or other laboratory studies) include plastic bags of different sizes and glass and plastic bottles, preferably with lids and of different volumes. In any case, they should be very clean. The containers must always be clearly identified and the contents should be adequately preserved either through refrigeration or, when necessary, using formaldehyde or a similar preservative. Alcohol or other preservative liquids can be used as long as they do not interfere with future tests.

As part of the investigation, documentation of the measures taken is important. The still or video cameras mentioned earlier, as well as tripods and lenses for special shots should be available for this purpose. These items should be taken into account during the emergency planning phase, or they should be acquired specifically for emergency situations.

Body preservation measures

Issues about preparation and final disposition of dead bodies will be discussed in detail later in this chapter. We touch on this topic here because preservation is required from the moment that human remains arrive at the place where examination, identification, and preparation for final disposition are done, particularly since these tasks are done in a staggered fashion.

The need for refrigerated holding areas should be anticipated, depending on the type and magnitude of event. Mobile or portable refrigeration units operated commercially (refrigerated containers or trucks) can be used. The morgue's refrigeration capacity surely will be exceeded during a disaster, especially if there are many unidentified bodies or remains recovered in the first hours of the event.

It is advisable to have refrigerated trucks that are used for routine commercial transport as close as possible to the body recovery site. They can be converted into temporary holding areas, keeping in mind the recommendations already made in the section on transport.

The use of other preservative measures such as quicklime (calcium hydroxide) and formol and zeolite will almost certainly be necessary, as well as commonly used disinfectants such as hypochlorite.

Temporary work camps or sites

The need for temporary work camps or sites depends on the type and magnitude of an event, the condition of human remains, the proximity to and accessibility of material and professional resources to deal with this type of event, as well as social circumstances at the disaster site.

Search and recovery of human remains and disaster relief activities in rural areas can last for days and sometimes even weeks or months. Temporary camps must be established for the personnel carrying out this work. These camps will also serve as an intermediate stop in the transfer of human remains. This should be taken into account in the disaster plan.

The examination and temporary holding of bodies and other medicolegal activities might have to be done under poor conditions, such as on boats or in sheds near the disaster site. In the case of earthquakes, for example, buildings existing for medicolegal examination and preparation of human remains might be damaged, or it may simply be impossible to access them.

In other cases, there are no medicolegal facilities in proximity to the disaster site or even in the closest community, or the capacity of existing facilities is insufficient to handle the workload. Temporary arrangements must then be made to work in other buildings or in tents or military huts. Access routes to these sites should be determined, and the ability to supply water and electricity should be ascertained. Again, these circumstances should be anticipated when developing emergency plans for each region.

When planning for temporary medicolegal facilities, at least three working areas should be designated:

- Holding area;
- Viewing area; and
- Examination area.

These areas will be different sizes and have different facilities depending on the type of disaster and the resources available at each site.

To facilitate identification of dead bodies, a provisional holding area, which is typically in an open space, should be set up to receive human remains following their removal from the disaster site. It is used while an initial description and classification are made, based on general features (race, sex, age, and stature) or other distinguishing features.

The holding area is used to receive dead bodies that are being transferred without undergoing examination because family members have been able to identify them, making it possible to release them according to certain legal provisions (we will return to this topic in the section on identification). Other reasons for placing bodies in the holding area are because family members are in the process of completing required legalities before they can take possession of the body; because the remains have not been identified; or because the body must be embalmed before being transported out of the country.

A private viewing area should be designated where family members and others will view photographs of the bodies, objects pertaining to the deceased, and finally, the bodies themselves. The procedures involved in visual recognition of the body are discussed in the section "Methods for identifying human remains" later in this chapter and in Chapter 5.

Examination space will be needed if it is necessary to conduct a more detailed exterior assessment of the body, provide a detailed description of the remains or fragments found, do an internal examination to confirm information received, take samples for laboratory studies, or make a complete autopsy.

The procedures outlined above justify the need to plan for the three working areas (holding, viewing, and examination), but it should be kept in mind that space for other activities also is needed. There should be spaces for documentation and provisional filing of information, for interviews with family members and others, for press conferences, and for briefings of experts, families, and claimants. Also needed are areas for cooking and eating, for sanitation services, for an infirmary (although minimal), and for other activities related to the management of dead bodies.

It is important to be aware of certain management principles regarding shelters and temporary settlements; these have been published in other scientific documents and have many features that are applicable to the temporary work sites. Among the most important are elements of hygiene and communicable diseases, control of access to these areas, provision of drinking water, and waste disposal. Other factors to consider include the placement of bodies, wind direction, and how the topography of the site will affect the flow of work.

Water and food

Water and food provision in major disaster situations is addressed in various publications about disaster management. This is vital to sustaining the mission, and the people responsible for organizing the emergency plan should give special attention to this issue.

Providing food and water to the victims and survivors of a disaster is a very complex undertaking, and it is no less complex to provide food and water to relief workers. Under no circumstances can we allow the improper handling of food and water to cause illnesses that will limit or delay the tasks of search, recovery, identification, and preparation of human remains.

All of the existing disaster management principles should be applied to handling food and water in emergencies, but some special conditions apply during medicolegal work, particularly relating to the consumption of water during work and the use of gloves. Generally gloves are worn, often surgical gloves, and in many cases they have to be reused after removing them, for instance after using the toilet. During long work days, water intake can be three to four times above normal. To save time, it should be possible to drink water during working hours without removing one's gloves by using disposable bottles and glasses or drinking fountains that can be foot-operated. If necessary, the task of providing water should be assigned to a specific person. In no case should there be open receptacles that can be easily contaminated.

Food should be distributed using comparable safety measures, avoiding items that can spoil easily and adapting the type of food to conditions at the work site and the climate. For example, when there is intense cold, the foods prepared should help to conserve body heat so that people can work for as long as possible. In severe conditions work shifts might have to be much shorter than usual, which affects calculations for the time needed to complete the work compared with normal conditions.

Medical care

Medical care is usually planned for victims, survivors, evacuees, and displaced persons in the context of a disaster. We must also take into account necessary medical treatment for the people responding to the disaster. This is not limited to treating injuries and other emergencies resulting from accidents, but for routine medical care that professionals and their assistants need. There is no doubt that relief workers will suffer from hypertension, diabetes, and other diseases that can easily change for the worse in emergency situations, particularly under the pressure of so much work and stress.

A good medicolegal disaster team should ascertain whether its staff will have any medical needs during the emergency and what medications they will need, and include these in an emergency kit. In addition, muscle relaxants, analgesics, and other medications for problems associated with muscle strain, as well as anti-diarrheal medications and digestives are frequently needed when many people are mobilized.

PARTICIPANTS

We have divided this section on participants into two groups depending on how they participate, their positions, and whether or not they have specialized knowledge or training in disaster management and the specific tasks they are expected to perform.

Disaster professionals

Health personnel

Ideally there should be sufficient medicolegal specialists available who have training in managing mass fatalities in disasters. In some emergency events it is possible to mobilize such a group of professionals in a timely manner, but this is the exception and not the rule.

We should at least aim to have a number of physicians, albeit limited, available to oversee the work. Preferably they will have received adequate theoretical training and some practical experience, and know how to integrate their actions with those of other participants such as fire fighters, rescue personnel from different backgrounds, police, criminologists, and others involved in disaster response.

Even in the worst conditions, a physician without training who uses his or her common sense and follows the basic principles presented here can perform with a certain degree of success. This is precisely our objective in writing this manual.

In the absence of forensic specialists, physicians, or dentists, the work of other professionals such as nurses, veterinarians, biologists, pharmacists, funeral administrators, and even gravediggers will be valuable. The latter, while usually having limited education, have sufficient psychological preparation to carry out the work when they receive adequate supervision. On more than one occasion we have seen professionals, including physicians, paralyzed by the magnitude of a disaster. They have been psychologically unable to assist in anticipated tasks, particularly in the recovery of bodies and body parts or in the most basic examinations needed to make identification.

Identification of remains might require involvement from forensic anthropologists or the use of regional laboratories to carry out genetic and toxicology screenings or simple photography and X-ray. The involvement of acting physicians in this work is especially desirable, but their absence should not be an excuse for delaying identification.

Outside assistance from both national and international sources should be requested when there is a very large number of dead bodies, and especially when they are of different nationalities as is often the case in aviation accidents. Forensic experts from different places can collaborate in tasks, or there should be at least one who is able to direct and organize the work. In accidents involving many nationalities, cooperation is needed to acquire the information needed to identify corpses; this is facilitated with the participation of experts from other countries.

It should be noted that search and rescue for survivors begin from the moment of impact of an event. The request for external assistance does not in any way preclude taking responsibility at the very beginning of the emergency. It is at this point that the physician who initially confronts the disaster should assert his or her knowledge and skill.

Police, firefighters, and other special forces

The police and firefighters generally have specialized training and organization in disaster response regardless of where they are from. To these we can add relief workers from the Red Cross and civil defense or comparable organizations as well as civil and military institutions that might include speleologists, special or assault forces, and diving teams, among others. For the best outcome there should be adequate planning and timely coordination with the expected participants in disaster response.

Experience shows that non-medical rescue workers sometimes give the same priority to the recovery of dead bodies as to the rescue of survivors. This may be because it can be difficult to make a timely diagnosis of death, but more likely it is because of a lack of training and inadequate preparation for this type of work. Resources and efforts are diverted unnecessarily to those who can wait—the deceased—to the detriment of the seriously injured survivors who cannot wait for assistance.

In most areas where professional fire services exist, they are fully aware of hazards and the potential for disasters in their own response areas. When health services in the same area are preparing their disaster plans, they should connect with the fire services and integrate their disaster response information into the health services plan. Where there are large industries such as oil and mining, among others, industrial safety specialists develop emergency response plans. Emergency medical actions can be derived from these plans and extended to the general community.

Criminologists and disaster specialists

Criminology is a science that has made important strides in recent years, especially in the application of new techniques to scientifically verify evidence used in investigations.

Some authors describe criminology as the branch of penal law that is concerned with scientific discovery of evidence of a crime and a criminal. For others it is the discipline that examines materials that can become proof of a crime committed by someone, and which is dedicated, among other things, to the study of the crime scene, of materials taken from the site, stains, projectiles, shoe and other prints, among other elements that give evidence of a crime.

There are many possible applications of criminology to disasters, ranging from documentation and study of the site of the event, investigation of vehicles linked to the disaster (especially aircraft and other kinds of transport implicated in major events), and the study of bodies, secretions, and other biological matter used for identification purposes.

Documentation of the site of the event, including in natural disasters, is of special interest since the study of a particular event will always be important. From the criminology perspective documentation should be done immediately and standard, digital, and video cameras are important for this task. In the absence of expert photographers, anyone with minimal knowledge of photography techniques can undertake this work. Even though the novice photographer will make mistakes, this is preferable to not having any photographs for later study.

With or without photographic media, drawings, sketches, and written descriptions of what is observed are the oldest and safest ways to keep a record of an event and in no circumstances should they be abandoned. The usefulness of even the most modern documentation methods will depend on the skills and availability of personnel who know how to operate the equipment.

Forensic genetics is one of the most important tools for the identification process. It uses classic blood groups of the ABO and Rh systems, immunological study of the human leukocyte antigens (HLA), and thanks to developments in molecular biology, DNA typing.

It should be noted that while these techniques are indicated in special cases, we recommend that biological matter be collected and preserved at the beginning of the investigation in case there is a need for it in the future. Identification is usually made by visual recognition of the victims or their belongings so laboratory tests are neces-

sary in only a limited number of cases. But without biological samples laboratory tests will not be possible.

When it is necessary to use additional techniques for identification, we should begin with the simplest and least costly, which are widely available. Contrary to what many lay persons believe, DNA is necessary in only a limited number of cases for identification.

The term "disaster expert" describes specialists from different disciplines who are dedicated to the study of disasters. There is no defined education in this branch of knowledge, which is a highly complex and broad field, encompassing a wide variety of disciplines such as engineering, medicine, dentistry, veterinary science, geography, seismology, meteorology, cybernetics, physics, and mathematics, among other sciences. In the case of forensics it is very important to use a comprehensive approach since a whole range of questions have to be dealt with in each situation, not only questions about identification.

Architects, engineers, and other professionals

It is not unusual today to see a wide range of professionals who are dedicated to studying and working in the topic of disasters. Among them are: architects, engineers (with specializations in civil, aeronautical, hydraulic, mechanical, geophysical, and electrical engineering), seismologists, nuclear physicists, geographers, and meteorologists, among others.

Their level of preparation and participation in the multi- and inter-disciplinary groups that cooperate to develop emergency plans for the zone or territory where they work can be vital for a better outcome in a disaster.

Journalists and media personnel

The role of the media in disaster situations is a very complex topic, especially because of the sensationalism that many of the world's communications media use to portray these events. Education about disasters for media personnel, especially regarding the management of mass fatalities in disaster situations, is essential. The media play a major role in guiding and informing the public about search and rescue, and about identification and preparation of human remains for final disposition.

Because of their informative role and contact with the public, the communications media can be useful in obtaining the necessary data to identify bodies that have been recovered but remain in holding areas because of a lack of information.

Judicial authorities

Judicial authorities are responsible for making decisions in cases that merit legal review. They might participate early in an investigation when it is linked to a violent act caused by humans, in which case someone might be accused of wrongdoing, prompting legal action. This is most common in traffic and aviation accidents, and in these cases judicial authorization is required to carry out many procedures, including autopsy and other forensic investigations, laboratory tests, and the release of human

remains to family members. For these reasons, judicial authorities should have knowledge of disaster preparedness plans.

Other participants in disaster response

Government and community authorities

In general, government and community authorities have little knowledge of disaster preparedness but they play a critical role in disaster response. Because the people occupying government positions change periodically, it can be impossible to ensure that their training is current. Consultants or advisors who are experts in disaster management are valuable and can be retained from one political cycle to the next.

Government authorities arrange for and decide on basic actions that range from early mobilization of a large number of the public safety personnel involved in the event, to the decision to request outside assistance when local resources cannot manage the emergency.

Since other major decisions are in their hands, they need to be receptive to the judgments of the experts, who in turn have the obligation to explain their criteria. Advisors should explain the best course of action to adequately manage a high number of fatalities.

Religious institutions and other local interest groups

These play an important role in most countries and can be very helpful in the organization of the community. They can help to provide basic information for identification files and assist family members in the process of identifying corpses as well as in the delivery of corpses to the family.

Morticians, gravediggers, and others

While not classified as "disaster professionals," morticians, gravediggers, and others might be among the most stable and well prepared to deal with emergencies with mass fatalities owing to their training and routine handling of dead bodies. However, they can also be negatively affected in these cases since they do not normally work with massive numbers of bodies.

Mortuary staff can offer very practical help, particularly because of their experience in dealing with family members and in preparing bodies for burial. In most countries mortuary services are responsible for complying with regulations for incineration and cremation, embalming, and making the necessary arrangements for transporting bodies, especially when the remains are repatriated. They should be included in disaster preparedness plans for these reasons, and their experiences should be heeded even though they usually relate to individual deaths.

Diplomats and consular representatives

Diplomats and consular representatives become involved whenever their nationals are caught up in a disaster. This is most frequently the case in aviation accidents or other types of transport accidents where international routes are involved.

Conditions should already be in place for attending to these authorities and coordinating activities with the corresponding ministry of foreign affairs. They can play an important role in finding information about presumed victims, especially by making rapid contact with family members and validating the information provided.

While this practice varies from country to country, frequently a consular office is present at the time the body of an identified victim is placed in a coffin and the coffin is closed, after which the body is transported to its country of origin. The presence of the consular officer provides official corroboration of the process.

Cooks and other service personnel

Cooks and other service personnel are very important in these emergencies since the work of search, recovery, and identification of victims can last for many days, with most of the time being spent at the site of the disaster. Water supplies and food are needed, as well as attention to other needs of mobilized relief workers. These services should be well organized whether provided by a contracted institution, catering service, or, if they have the capacity, by the agencies directly involved in disaster response.

Other needs should be kept in mind such as the availability of sanitation services, washing facilities, dining areas, a small infirmary, telephone booths for calls of family members and other staff at the site, as well as a taxi service for people who come to the disaster site and need transportation to areas where corpses are being held and released. This type of service is important in remote areas where taxis are not commonly available, particularly at night.

Family members, neighbors, and the general public

Family members, neighbors, and the general public are nearly always present from the beginning of an emergency, before the authorities arrive. They can assist or hinder in the early work of responding to a disaster. For this reason it is important that the public receive education in anticipation of an event and have good leadership once a disaster occurs.

All family members of the presumed victims must be given preferential treatment. It is especially important that they receive information regularly even though it comes from a centralized source and may not directly apply to their loved one. It should be understood that families are anxious and undergoing difficult times and as a result will not always behave rationally.

OPERATIONS COORDINATION

The work of assembling and directing a multidisciplinary team in disaster conditions, especially where there are mass fatalities, can be extremely complex regardless of the physical conditions at the site or the material resources available. Experience shows that this work will be effective when participants are well prepared and the coordinator of operations has the necessary knowledge, authority, and leadership skills. When these conditions exist it may be possible to avoid the dreaded and all too common "disaster on top of disaster" caused by disorganization, lack of coordination, despair, and improvisation. Having too many chiefs without a mandate and many workers without any guidance will have negative results.

The following sections summarize aspects of operations coordination in disasters with mass fatalities and is based on the accumulated experience of experts from different countries. Each case should be adapted to the existing conditions in each area and to the type of disaster being faced.

Search for information

Information is the basis for decision-making today more than ever, and it is essential in disaster situations. Simply knowing about the event that we are facing, the probable number of fatalities and condition of human remains, or prevailing weather conditions, to name only a few variables, will significantly affect how we respond.

The place, the event, and the hazards

Once advised of a disaster, we need some basic information to allow us to better implement the emergency plan. It is presumed that the plan was prepared during normal conditions and considers variables according to the place, the type and magnitude of the event, conditions for operations, available resources, and other aspects particular to a specific type of event.

Soon after the impact of the event, the physician or other professional who is summoned to coordinate the management of massive fatalities should determine or estimate as precisely as possible the following:

- The type of event;
- When and where it occurred;
- Actual or potential number of victims, including the number of fatalities;
- Location of rescued victims, including dead bodies;
- Accessibility of the disaster site, survivors, and holding area for dead bodies;
- Estimated time to recover dead bodies;
- The condition of the bodies, their presumed identity, and the presence of foreigners;
- Potential hazards existing at the disaster site;

- Current weather conditions and forecasts; and
- Availability of resources to respond to emergency.

Presumed victims

When notification of the disaster occurs, there may be no idea of the actual number of victims, including the number of dead, or their identity. On the contrary, there may be information about an estimated number of victims and their presumed identity (for example, crew and passengers of an aviation accident). These circumstances affect the approach to removal and identification of dead bodies.

Once there is a general idea of the identity of presumed fatalities, an immediate search should begin for the information needed to create identification files corresponding to each case. Directing this process is one of the most important tasks for the coordinator at this stage.

- Among the most common sources for basic information are interviews with people who have close ties to the victim, including:
  - Relatives, friends, neighbors, classmates, teammates, and work colleagues;
  - Physicians and dentists;
  - Personal nurses, physiotherapists, or podiatrists;
  - Tailors, seamstresses, or clothing retailers;
  - Photographers, jewelers, hairdressers, and masseurs linked to the victim; and
  - Survivors and witnesses of the event.
- The search, receipt, and review of the following kinds of documents also yield essential information:
  - Personal identity documents;
  - Registration papers, especially those with fingerprints;
  - Photographs and videos of the subjects and their belongings;
  - Medical and laboratory records and x-rays;
  - Dental records, including x-rays and dental charts;
  - Receipts for the purchase of clothing, watches, jewelry, etc.
- Articles that can be used for comparison include:
  - Clothing and shoes examined for size, wear, and odor;
  - Personal combs with hair from the subject or hair from another source;
  - Objects touched by the subject moments before the event;
  - Preexisting stains from the subject found on a variety of objects;
  - Samples from immediate family members to be used for forensic genetic studies; and
  - Dental impressions or prostheses.

Keeping in mind that identification is based on the comparison of information obtained from human remains (post-mortem data) with information about the presumed disaster victims (ante-mortem data), it is essential to set up an identification file with data for each of the persons presumed to have been involved in the event. This allows us to classify the victims for more rapid medicolegal processing. It is better still if the information can be processed with computers and software created especially for these situations.

Gathering information about presumed victims is a very important phase in the investigation. With the exception of people such as aviation personnel or others in high-risk occupations who have intentionally provided information in advance because of the possibility of an accident, an identification or data file is generally created after a disaster. This comes at a very difficult time for the people who should be able to provide basic information since they are usually the closest to the presumed victims. They might initially refuse to cooperate because they do not want to face the reality of their loved one's death, or they might provide incorrect data because of their state of mind at the time of the interview.

Whenever possible the interview with family members or associates should take place in a suitable setting using all possible resources to gain the cooperation of the subject, including the support of psychiatrists and psychologists when deemed necessary. It is important to evaluate how confident the interviewee is about the information he or she is giving. Particularly when working with a closed group of victims (i.e., the number of victims and their presumed identities are known, as, for example, in an aviation accident), one mistaken piece of information can be enough to lead to multiply errors in the identification process.

When various informants are interviewed about the same person, there will be differences in the information they give. It is advisable to establish ranges for the supplied data that will finally be used. Generally maximums and minimums are taken, for example, a height of 165 cm to 170 cm, or an age between 22 and 24 years. In some cases unreliable data will be provisionally removed from the final file, or the questionable data will be included with an explanatory note. A common mistake occurs when interviewees try to describe something on the body of the presumed victim and they confuse the right and left sides. This is due to our perception of the opposite side of the person or object we face in relation to our own body. It is not unusual for the interviewee to say that someone is missing the upper right canine when in fact the left one is missing, or that someone broke their left forearm as a child when it was actually the right one.

It is advisable to choose from among the many data collection forms that have been developed by experts from all over the world. The forms should be adapted to reflect the characteristics and vernacular of the region where the disaster occurred and which are presumably shared by the person conducting interviews. It is important to keep in mind that a word can have very different meanings in different regions or will not have any meaning for the interviewer. For example, the words "lame," "halt," and "crippled" are synonyms but might not be descriptive to someone who is not familiar with the terms.

Part of the information for identification will come from a search for basic personal data (ante-mortem data). This information, which may vary depending on circumstances and the person interviewed, would generally include the following::

- Clothing that the victim wore, including type, color, sizes, characteristics, brands, and other details;
- Jewelry worn, including type, amount, shape and color, sizes, characteristics, markings or inscriptions, and other details;
- Documents carried, including type, number, and location, among other details;
- Documents that the victim did not carry, including photographs that can be used for comparison, and hand- or fingerprints of the subject;
- Medical files and other documents with clinical information;
- Characteristics of the presumed victim, including age, gender, race, and stature; scars, blemishes, birthmarks, or tattoos; hair color (natural and dyed) and characteristics; presence of moustache or beard, and their characteristics; dental prostheses, dental chart, and other dental studies; blood type and other genetic information; x-rays and other relevant laboratory tests; data about any ante-mortem trauma, abnormalities, and orthopedic and other prostheses; known illnesses; surgery experienced and special consequences, if any; and any other particular information for each case.

Collecting the information outlined above is the basis for comparing corresponding characteristics from the examination of human remains, thereby establishing an identity for the dead person.

This information can be saved on computers using software developed for this kind of work, or databases can be created for a specific event. Lacking this technology, it is still necessary to organize the information so that it can be processed easily, expediting the comparison of data from the examination of recovered bodies with data provided in interviews with relatives. There are various methods for processing these data and the experts should be aware of the most appropriate considering the available resources.

REMOVAL OF DEAD BODIES

From the moment a disaster occurs, there begins one of the most complex and generally least professionally performed processes in disaster response, which is the recovery of dead bodies. This nearly always becomes a confused and disorganized removal of human remains from the disaster site by many different people and only rarely by the acting physicians in disaster operations.

The removal of human remains from a disaster scene is one of the most important aspects in the investigation of a presumably criminal act from the medicolegal, criminological, and finally judicial perspectives. In most disasters suspicion of a criminal

act is not adequately considered at the outset of the response, which can hinder the investigation in many cases. Unfortunately, in events where criminal motive is likely, as in aviation disasters connected to terrorist activity, the investigation aspect is neglected. This occurs because of lack of knowledge about investigation methods, shortage of personnel who can complete the work efficiently in the short term, and the intense social pressure to remove bodies from a disaster site.

It is very difficult to use scientific investigation principles at the disaster site, especially because of the psychological and political pressure that surrounds such events. It becomes a "priority objective," although without any scientific basis, to rapidly remove the human remains from the site. This hurried response poses the risk of destroying evidence that could explain the event or even facilitate faster identification of victims, particularly in cases where there are body fragments.

Notwithstanding the pessimistic assessments made above, which are based on a reality experienced over many years, the doctor or professional responsible for the difficult task of coordinating and carrying out the removal of corpses should understand the methodology, and above all have the staff and support necessary to perform effectively. Even when corpse removal cannot be carried out correctly, using established scientific methods, the physician or professional in charge should try to save as much evidence as possible, and above all document the scene with still photography and video, even though the photography equipment is not professional. Photographic evidence of the scene can be important later for the experts who attempt to resolve unanticipated medicolegal problems associated with the disaster.

Procedures at the disaster site

Once notification of the disaster is made, specialists and their assistants are transferred with the transportation available to the disaster site where, according to the type and magnitude of the event, they might be carrying out such parallel actions as search and rescue of the survivors (injured or not), removing rubble in different areas by hand or with machines, extinguishing fires, and controlling toxic gas leaks, among other activities.

As can be seen from this simplistic description, in most cases the disaster site is the focus of intense activity. A great many people are present and unfortunately many of them do not have a definite plan of action. They may have entered the site despite security measures and restrictions on access. Their assistance is spontaneous and arbitrary, and many times they take on a leadership role for which they have neither the skills nor necessary experience. These difficult conditions are the backdrop for the important work of coordinating the survey and removal of corpses that has been assigned to the acting physician.

There may appear to be many supervisors, and on more than one occasion it has been almost impossible to determine who is in charge. It is important to define who the law establishes as having maximum authority, and in collaboration with other agencies, follow the procedures as they have been designed for the case in question. Waiting until it is decided who has the legal authority to supervise can create major problems.

Without using a specific example it is difficult to explain where and how to begin the process of survey and removal of corpses. Certain principles should be kept in mind when making decisions about the most appropriate strategy to use. For example, we should be aware of the total possible dispersal area of human remains, the immediate accessibility of all the affected areas or exposed bodies, and whether other resources are needed to reach them. It is also essential to know the number and condition of remains, effects from fire and other agents, among other features.

The site should be divided into work zones in order to organize the process. Preferably the area should be defined by existing fixed objects, using a sketch with each activity consecutively numbered. This allows an efficient and simple reconstruction of the approximate location of each body or fragment after it is removed from the site.

The cardinal points must be located as reference points, and a calculation made of the approximate total surface area of the disaster site, especially the area where bodies and body parts are dispersed. This area is recorded on a map or basic sketch. It is useful to place flags or stakes, paint signs, or use other markings or reference points when there are no fixed objects to give adequate orientation. If conditions permit it is helpful to make a rapid topographic survey of the site and fix features related to the event to assist in defining the work zones.

When certain conditions are present, the location of groupings of human remains will be described. These conditions include:

- The number of dead is high and there are more than five dead or presumed dead for each specialist (a specialist in forensic medicine with training in disaster management). The standard tasks required will be body removal and possibly complex identification activities beyond simple visual recognition;
- The disaster site is very large, i.e., more than 5,000 m^2 per specialist;
- The human remains are widely scattered, covering an area greater than 1 km^2;
- The bodies are in areas that are difficult to access and they cannot be reached quickly via ground transportation.

Under these or other special conditions, descriptions made in the survey should signal only the most significant elements that are of medicolegal interest. These would include: the position of the body; the location of exterior wounds and their relationship to objects at the site that may have caused the injuries; proximity to a secondary fire source, or on the contrary, burns without evidence of fire in the immediate vicinity of the body. In the case of traffic and aviation accidents, specify whether the bodies are inside or outside of the vehicle and whether safety belts are fastened, and note evidence of objects in the vicinity of the body that might have caused injuries, and other aspects of general medicolegal interest.

One topic of debate has to do with numbering the corpses that are being recovered, especially when there are several acting physicians. This need not be a controversial issue: whatever the method or coding used, it should be able to reproduce or approximate, even in just a sketch, the location of each body, establishing the relationship between the bodies and objects around them, and at the very least, indicate from which zone of the disaster site the body was removed.

A simple method is to assign a letter to each acting physician (A, B, C, etc.) or a letter that relates to his or her name (P for Peter, R for Ray, M for Mary, etc.), noting the zone he or she is assigned to work. After these zones are assigned to each physician, begin coding remains with number 1 and number them consecutively until the assigned work area is completed. When the human remains arrive at the holding area or temporary morgue they will be identified with consecutive coding (for example, A-1, A-2, A-3 or P-1, P-2, etc.). A sketch of the area showing where each recovery was made serves as a record of the process.

There are specialists who can carry out aerial topographic surveys prior to the removal of the corpses using still photographs or video. This sort of survey is possible when weather and conditions at the site allow it, and assuming resources are available. However, this type of survey does not exclude or substitute the individual or group survey described above. It is essential for physicians to receive basic training in performing the survey since it is one of the first things that he or she will do in a disaster situation. Because of its urgency it nearly always will have to be performed before specialists arrive at the scene.

The physician's basic survey report should include the following:

- Code number of the document;
- Name and code of the acting physician;
- Exact hour, date, and place of the activity;
- The authority requesting the action;
- Integrity of the bodies (complete body, body fragment, commingled remains, tissue mass, etc.);
- Estimated age, sex, race, and skin color, if recognizable;
- General description of clothing (the most significant or identifiable features);
- Documents accompanying the body and names appearing on them;
- Jewelry on the body;
- Position, injuries and elements related to the date of death, among others;
- Correlation between injury and site of the event and other information about the scene; and
- Signature of the acting physician.

When it is possible to surmise the identification of a victim because of documents found during recovery, including corresponding photographs, it is advisable to put a final note in the document stating, "Presumed identification is…." The code assigned for the recovery should be circled or marked in some way to indicate that a preliminary identification has been made. This will assist in classifying bodies as they arrive at the holding area or temporary morgue.

One concern is how to register the code used during the removal when the integrity of the body is compromised and there is only a fragment or tissue, the body is decomposed because of the time since the event, or the body is charred. In such cases it is advisable to remove the remains using body bags; if body bags are not available use something similar that is strong, or use doubled or tripled garbage bags. Write the

code assigned to the case with a contrasting color of indelible ink on the outside of the bags, which are usually white, black, or green. The code also should appear on two small, metal identification (ID) tags that have been stamped or at least written on with indelible ink. One ID tag is tied with wire or strong cord (preferably a synthetic material) to a secure part of the body or fragment, while the other is attached to the closure of the bag or somewhere visible if the bag has a zipper or clasp.

When a body is recovered within a few hours of death, some authors recommend placing a third ID tag inside the mouth since rigor mortis will cause the mouth to remain tightly shut and under no circumstances will the tag be lost. The disadvantage is that to extract the tag to check coding, incisions have to be made to release the rigidity of the mandible. For this reason some experts recommend attaching tags to the exterior of the body.

The plastic bracelets used in hospitals for patients and in hotels as guest identification are a good option for tagging corpses. They are strong, of good quality, and each can be pre-printed with its own code. One limitation is that they are difficult to attach to bodies that have missing limbs. Another consideration is that the coding on the bracelets will not be randomly assigned. Unlike the more traditional type of tagging described above, if one does not complete the work oneself, the bracelet will not have the information giving the number and order of removal or the physician who did complete the work. An additional control system would have to be established to include this type of information. For these reasons bracelets are more appropriate for use in reception and holding areas where there are facilities to work with the human remains rather than during the complex recovery phase.

As is obvious from the above discussion, the physician will need several assistants for the survey and removal of corpses. They should have stretchers to move the human remains as well as enough bags and coded identification tags (stamped or painted tags, plastic bracelets, or other measures mentioned). The removal of the remains must always be done in the presence of and under the direction of the acting physician.

No examination of the bodies should be done at the disaster site with the exception of checking pockets of victims' clothing to look for identification documents. Any information about documents should be immediately annotated in the survey and corpse record. After describing documents found when checking the bodies at the scene, they should be identified with the same code used for the corresponding corpse, and placed in clear plastic bags so that they can be read without having to open the bag. Other experts recommend that documents be returned to the place they were found (for example, a pocket), and only removed during the final exam of a corpse at the temporary morgue or holding area. In either case, a photographic or video record made of the documents should be registered using still photography or video at the disaster site.

Documents might be found during the surveys that are not directly linked to any of the bodies. They should be recovered, put in a bag, and placed where they were found at the site. Note should be made of the closest body or bodies to the documents, and they should be given a predetermined code that is used only for document identification.

Jewelry found on the bodies should not be removed. Articles should be described and left in position until the detailed exam and description are done at the holding area. Photographs and videos will help the people who recognize the jewelry to identify the corpse. Even with photographic documentation, a detailed description of the jewelry should be made.

Transfer of human remains

Once the survey work is complete and the human remains are removed, they should be gathered at a holding area close to the disaster site where they will be examined or transferred to the site where final examination and disposition will take place. The location of the holding site will depend on many factors, including: the number of dead that have been recovered, the condition of the corpses, the distance from the disaster site to the closest morgue or autopsy facility (whether at a hospital or medicolegal institute), and the refrigeration capacity of these facilities, among other factors.

The human remains should be well packed in bags with corresponding identification, transported in trucks or vans (preferably closed vehicles), and refrigerated, if possible. The recommended temperature for preservation is 4 ºC. We should warn against freezing the bodies since that will make immediate tasks such as detailed description for identification purposes more difficult. Freezing will also interfere with autopsy, although autopsy would normally only be carried out in special cases.

As mentioned earlier, the human remains should not be transported individually in ambulances or health service vehicles. If there is a shortage of health service vehicles in normal times, it is much worse during a disaster situation. In any case, even though the bodies are in well sealed bags, it is advisable to cover the floor of the vehicle to avoid possible contamination with liquids that might leak from the bag, especially when dealing with body fragments or tissues or when bodies are decomposed. As explained in the section on transport, it is important to cover any identifying markings on vehicles used to transport or hold corpses.

Holding and examination site

Once corpses are recovered and transported to the holding site, other studies will be undertaken, the most important of which is identification (we address identification methods later in the chapter). We should note that the demands on experts in each case may vary, and it is necessary to plan for the working conditions and space required for different tasks.

Regardless of the type of disaster, certain minimal conditions must be in place to carry out the examination and temporary deposit of the bodies. Some of these requirements have already been discussed in the “Material needs” sections of this chapter, but others may arise depending on the circumstances.

As mentioned earlier, control of access and availability of water and lighting are some of the basic requirements that should be taken into account for temporary working areas in disaster situations outside of a mortuary or medicolegal institution. At

least three working areas will be needed: the holding area, viewing area, and examination area. The size and characteristics of each depends on the nature of the event and the resources at the site.

Holding area

The human remains will be placed in a holding area as they arrive from the recovery site. The holding site must bring together certain basic conditions ranging from privacy, which is essential, to a place out of the sun where corpses can be placed, thereby slowing decomposition. In tropical countries or where temperatures are high it is advisable that this area be refrigerated to try to avoid decomposition, which is likely especially as a result of the injuries sustained.

The bodies should be arranged on their arrival to facilitate identification by classification. They should be placed in predetermined spaces, and classified by groups according to sex, skin color, and age. Other classifications can be added such as biotype and color and length of hair, and later, elements that require measurement, such as height and foot size, among others, can be added.

One aspect of identification can be accomplished at the same time that a corpse is transferred to the holding area. For example, if there are 150 presumed victims of the disaster and someone is looking for an elderly black man, who is tall and thin, there might be only two or three corpses matching that description. By placing corpses in defined classification areas, the task of determining which victim is being sought is considerably simpler. For the person seeking the elderly man, there are now not 150 victims, but the two or three who meet certain criteria, have already been placed in a defined holding area, and can be found quickly.

This holds for any case. For example, if someone is seeking a young woman who is white, short, heavyset, blond, and described as being pregnant, it may be that only one of the 150 victims have those characteristics. If victim transfer is well organized, it will be possible to immediately identify her body when it arrives at the holding area.

There are various computer programs that can assist in managing the massive amounts of information involved in identification and disposition of human remains in disaster situations. However, in the absence of computers we can use a classic method using cards (known as “McBee” or “keysort” cards) with holes around the edges, each of which is assigned one of the identification criteria. By inserting a wire or long needle through one of the holes it is possible to manage information for hundreds of cases rapidly and efficiently.

For example, assume we assign “male” to hole No. 1, “female” to hole No. 2, and “undetermined sex” to hole No. 3. When entering information about a male victim on a card, hole No. 1 is notched to the edge of the card. In order to select cards for male

victims, a wire or long needle is inserted through hole No. 1 of all the cards. Cards are lifted simultaneously and those with notches at hole No. 1 will drop out of the stack of cards. From hundreds of cards it will be possible to know in seconds which correspond to males. This operation is repeated for each criterion and each time there will be fewer cards with which to work for the case in question. The universe of victims is reduced as more identity parameters are available. We will return to this selection approach when we discuss identification.

Viewing area

Visual recognition may be necessary for identifying a corpse. This identification process is codified in many countries and is an important element of routine medicolegal work, not only in disaster situations.

It is important to have a viewing area for family members, friends, or others who can help in the identification. First, photographs of jewelry, clothing, or identifiable objects or features found in the examination of the human remains will be shown. During the second phase family members and others will view photographs of the bodies and especially of the face if there are features that can help with identification. In the third phase, objects and, finally, the remains themselves are shown directly to family members or associates to conclude the visual recognition phase and obtain the desired identification.

Of course this task should be done with great care, gradually, and taking required ethical considerations into account. The relative or person collaborating in the identification should be psychologically prepared. As in all medicolegal endeavors, the results must be skillfully interpreted.

We insist on this last point, since it is not enough that the persons to whom we show the photographs of jewelry or clothing or even the body or fragment say that an item belongs to a person or positively identifies a body or fragment. An interview should aim to determine the reasoning behind their responses, and should verify their knowledge about what they are saying. Their responses should be observed very closely even when they are directly identifying the body or fragments since nervous tension or simple rejection of the death of a relative or close friend can lead to mistaken or unrealistic responses.

Examination area

Since it is always necessary to examine the exterior of the human remains, including clothing, an examination area is needed.

Autopsy is not necessary for all victims of a disaster, although it is advisable in some cases and essential in others. A station for conducting autopsy is needed in the examination area.

In addition to an autopsy station, there should be work areas for other examinations made selectively on the corpses. Some examples are: evidence of whether an appendectomy has ever been performed, an examination of the mouth to review dentition, extraction of the humerus for measurement, or calculation of a subject's age

by examining the trabeculae of bone in the skull. It might be necessary to take biological samples for toxicology screenings, especially for alcohol, which often are obtained by needle puncture. Other samples might require opening of cavities, including evisceration.

Embalming or other techniques to preserve the remains can be done in the examination area. This area can also be used for sealing coffins in the presence of the appropriate authority. It is essential to have a work area that meets the minimal requirements for a temporary or field morgue to carry out these procedures.

METHODS FOR IDENTIFYING HUMAN REMAINS

There is great variety in the situations presented by disasters, and the conditions and possibilities for identifying disaster victims are also unpredictable. These range from considering the integrity and preservation of the corpses, to determining whether the victims are local or are predominantly foreign. Other concerns are the availability of disaster experts, particularly those with forensic expertise in identification, as well as the feasibility of finding the information needed to establish the presumed identity of a victim.

In the next sections, we present general methodology for establishing identity of disaster victims, beginning with the most elemental methods and advancing to sophisticated resources to resolve a particular case.

Identification using visual recognition

Once the remains have been recovered, examination of the exterior of the body and clothing will take place. Even though a presumed identity was made during the recovery, it must be certified after conducting an exhaustive exam.

Following the external examination, we proceed to classifying bodies, usually by sex, age, skin color, and if necessary, and depending on the integrity of the body, approximate height. Color and length of hair might be important for classification as well as features such as scars, prostheses, birth marks, and information about clothing and jewelry, among other items.

As discussed earlier, remains can be placed in groups or subgroups according to individual identification criteria in a level area or courtyard that is divided into sections, or inside a refrigerated container or vehicle.

To give an example, in each sex grouping there are several subgroups. The males can be divided into four age groups: children, youths, adults, and elderly (the range of ages should be specified for each subgroup). Each age group can be divided by skin color (for example, black, mestizo, and white), without using anthropological precision regarding race. These subgroups can then be classified according to hair color (black, brown, or blond). This continues successively with each characteristic that we use as an individualizing trait.

For example, in an aviation disaster with more than 150 deaths it is possible to make a rapid search for one individual according to the above classification system. With a

minimum of three traits, i.e., age, sex, and skin color, it is usually possible to match only 4 or 5 of the 150 victims. This can then be refined to other characteristics, some as simple as hair length. It might not be possible to classify all victims using this system because of the condition of the remains and lack of identifiable features.

Once the majority of bodies are arranged using this simple method, and after the remains have been examined and prepared by the forensics expert, they are presented to relatives, friends, associates, or others who can help with identification. This constitutes the so-called "visual recognition" process, which clearly requires prior organization. A written record of the elements that contribute to the presumed identification will be included in the file.

The identification process follows certain basic principles that can be summarized as follows:

- Converse with and prepare the observer psychologically in order to assess his or her actual knowledge of the presumed victim;
- Conduct the identification individually, not with groups of people or in the presence of other corpses;
- Use a place that has adequate lighting and privacy;
- Position the corpse carefully, ensure that it is clean, and cover any affected areas that would make a strong, negative impression on the observer;
- Do not remove clothing, jewelry, or objects that might influence direct observation, particularly eyeglasses;
- Show the observer areas of the body that might confirm information given during the interview, such as scars, tattoos, birthmarks, and blemishes, or dentures and prostheses if applicable;
- Verify each piece of information that the observer provides, even regarding features that are not visible, such as possible surgical procedures; and
- Prepare a written record and, if possible, film the process, explaining elements provided by the observer and any possible contradictions.

Once visual recognition is complete, which sometimes involves successive viewings by several individuals, verify whether or not the information provided coincides with what was obtained in the examination. Some of these elements would include: calculation of age, presence of specific dental work, verification of foot defect that affects footwear, or confirmation of an appendectomy, among other elements.

It has been scientifically demonstrated that in the vast majority of cases identification can be made using this technique, except when decomposition, burns (in particular, charring), or the severity of injuries (only fragments of the body remain) prevent these valuable judgments.

Identification using anthropological studies

Visual recognition is used to identify the great majority of those killed as the result of a disaster, as well as survivors who, because of their condition, can not provide information. A small number of corpses need more thorough study either

because of the extent of damage, especially to the face, or because there are not enough distinguishing features to establish certain identity. In these cases anthropological examination is an option.

In the case of victims who have been dead for a long time, it is very likely that technical verification will have to be done since simple visual recognition rarely solves the problem. We are referring to decomposed and even skeletal remains. This is very rare in disaster situations, but could occur in the case of accidents where aircraft disappear in jungle areas or in areas that are so difficult to reach that by the time victims are located decomposition or skeletonization has set in. The same may apply in mudslides and landslides when recovery of bodies is delayed.

In general, we speak of identity of the living and identity of a corpse. The latter is subdivided according to whether the death is recent or not, which is the same as saying that the body is or is not in a state of decomposition, the final phase being skeletal remains.

While it is unlikely that one will deal with skeletal remains in disaster situations, this does not rule out the use of anthropological methods. This discipline is dedicated not only to the study of bones, but also to studies of living subjects, and in a similar way the recently deceased (using somatoscopy and somatometry).

Absolute identity always should be established, and while we can only verify certain aspects of identity (i.e., age, sex, race, and stature), these aspects are sufficient to make a preliminary identification of the presumed victim. We then look for other elements that allow us to establish identity with greater certainty.

A general outline of activities, which is almost the same for the living as for the recently deceased, includes:

- Interviews with people who can provide information;
- Somatoscopic studies (including biotype, scars, tatoos, and other markings);
- Development and characteristics of hair (including length, color, and style);
- Genital appearance and development (description of external genitalia);
- Dental development and information (dental chart and dental anthropology);
- Bone development and information (evidence ranging from ossification to fracture);
- Somatometric studies (from foot size to height); and
- Possible diagnostic imaging comparison.

When the examination is of skeletal remains, it is advisable to proceed with the following tasks:

- Set up a preliminary file for comparison of elements;
- Prepare biological material for study, especially bones;
- Make observations of the bone;
- Locate ante-, peri-, and post-mortem injuries that will assist in identification;
- Look for bone disease and suspected bone anomalies;

- Take necessary measurements of the bone and make comparisons;
- Conduct diagnostic imaging studies of the body and cranium;
- Do odontological and stomatological studies, including dental anthropology;
- Superimpose skull and ante-mortem photographs, if warranted;
- Assess sculptural reconstruction, if appropriate;
- Conduct other tests as required.

These examinations support or exclude identity and in many cases a single test can rule out positive identification. In general, several tests are made and when all coincide we can establish the identity unconditionally. Results should be recorded in the report, which then can be complemented by other contributions. The interpretation of some tests can be misleading. For example, superimposition of skull and ante-mortem photographs can only exclude remains; simple coincidence in this test does not confirm the identity of the subject.

The osteologic study begins by determining whether bones are indeed human, which bones are present, whether they are from the right or left side of the body, and how many skeletons there are when remains are commingled. In direct observation of the bone we can describe the appearance and fusion of the epiphyses, whether cranial sutures are closed, the condition of bone trabeculae and the spinal canal, the presence of malformations and bone disease, racial and sex characteristics that can be determined from the skull and pelvis, and the presence of recent or old injuries to the bone that have caused typical deformity.

Other methods of identification

Any of the following studies can also be performed:

- Cytology,
- Fingerprint comparison,
- Forensic genetics,
- Molecular biology, in particular, DNA,
- Writing analysis, and others.

DNA IDENTIFICATION*

Historic background

Identification using molecular tools began with systems to determine relationship or parentage based on Mendelian inheritance using blood types. Information derived from blood types has a very low rate of accuracy owing to the limited number of

* This section on DNA identification was prepared by Beatriz Lizárraga, Raúl Tito, Paul W. López , and Gian Carlo Iannacone from the Molecular Biology and Genetics Laboratory, Legal Medicine Institute of the Public Ministry of Peru, and Project for the Study of Polymorphism of DNA Markers in Peruvian Populations, of the Biochemistry and Nutrition Research Center, National University of San Marcos, Peru.

marker combinations. Following this they developed markers from human leucocyte antigens (HLA), a complicated system used primarily to verify the compatibility of tissues for transplant, a process that is rarely available for use in forensic laboratories. However, neither blood typing nor HLA typing can provide the variability that is needed to individualize subjects and, as a result, are not used for identification.

Regions known as microsatellites are found in the chromosomes of any species; their very high level of variability in populations favors their use as molecular markers. The variability found in these regions derives from differences in the genetic material in the same nucleotide sequence, through substitutions of nucleotides, or in the distinct lengths generated by the same sequence that is repeated over and over again. This was demonstrated for the first time by Wyman and White in 1980.

Despite the evident usefulness of microsatellites in tracking inheritance, and, therefore, for determining identification, reasons of a strictly technical nature restricted their application. In the mid-1980s developments began for identifying individuals based on the study of DNA polymorphism, which reflects the wide variation of sequences located in different regions of the genome. Researchers were able to develop specific systems for each species, including the human species.

Beginning in 1990, analysis using the polymerase chain reaction (PCR) technique gained currency in forensic laboratories owing to the relative simplicity of the technique, lower cost, and simple interpretation of the results, but above all because it requires minute quantities of DNA. DNA identification has gained scientific acceptance for forensic investigation and its power of discrimination has been validated, especially in cases that exclude biological relationship. Among the DNA identification systems, the analysis of nuclear genetic material is very informative owing to Mendelian inheritance, that is, half of the offspring's genetic content is inherited from the mother, and half from the father.

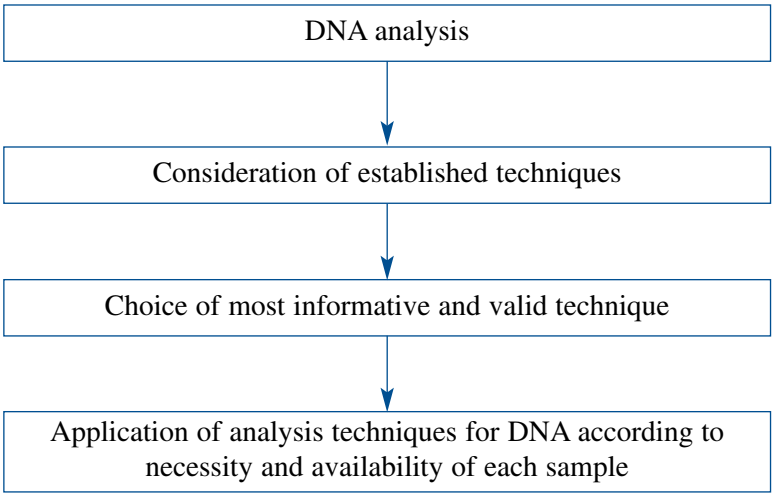
Difficulties with the PCR identification system have to do with the susceptibility of the DNA molecule to chemical modification by substances such as formalin; to structural loss by reactions with sodium hypochlorite; and finally, if it is has not been digested by natural enzymatic processes, with time it begins to fragment through loss of regions that have a high content of adenine and guanine. However, if the samples used for obtaining the polymorphic profiles of each individual are recent or have been correctly preserved, the Combined DNA Index System (CODIS) will give results. If the samples or tissues to be used for obtaining DNA for analysis are stored at room temperature, the DNA will continue to fragment and it will not be possible to establish genetic profiles.

In some samples, such as small blood or semen stains, saliva, hairs, old corpses, or remains from massive disasters, DNA techniques provide the only chance of obtaining a genetic profile.

On the other hand, there is also a heredity pattern of a special type of DNA present in the cellular organelles known as mitochondria. The information contained in the mitochondrial sequence is inherited exclusively through the maternal line, so the link between people related maternally can be established and allows differentiation of individuals of distinct lineages. This feature, added to the fact that each cell contains a large number of mitochondria, that the mitochondrial DNA is less susceptible

to the chemical and physical modifications mentioned earlier, and it presents a region with a high mutation index (hypervariable region), makes this system very useful, especially in cases of highly degraded material. For the maternal relationships in humans the human mitochondrial genome sequence is used.

DNA identification process

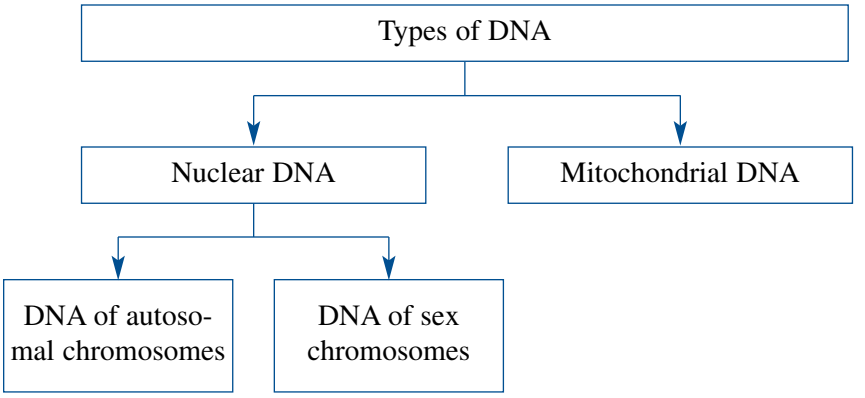


Currently in human identification cases both traditional anthropological methods and molecular methods are used, thus increasing the number of positive identifications. For example, in the Mesa Redonda fire disaster (discussed in Chapter 7), we were faced with making identifications in very complex cases resulting from a mass fatality event, so there was a need for DNA analysis in this instance. We should point out that the percentage error when using classical methods is 15 percent.

It is for this reason that methodologies for human DNA analysis have been chosen to be used as an identification tool. These techniques have demonstrated high reliability when typing the remains corresponding to unidentified individuals in disasters with massive fatalities worldwide. This clearly depends on the type of sample, the degree of sample preservation, and the period of time that the sample has been exposed to outside agents (for example, fire) as well as the environment.

The use of methodologies related to mitochondrial DNA generally are restricted to samples showing a wide range of deterioration, such as very old skeletal remains. Lacking more complex analysis methods, this type of analysis provides resolution or approximation in the majority of cases, due to very specific technical features. Analysis using mitochondrial DNA has the limitation of not being as informative as analysis of nuclear DNA.

When identification cannot be determined using anthropological methods owing to the loss of phenotypic characteristics, identification of the remains will only be possible using molecular techniques (DNA test), a very complex process that requires the use of highly technical equipment and specialized professionals.



Prior to beginning the identification process it is important to have information about the group that will be studied, classified by type of population:

Closed population: the number of corpses coincides with the number of registered victims;

Open population: the number of corpses does not coincide with the number of registered victims, and in many cases will be higher.

DNA identification is based on the correspondence that exists between the genetic markers of progenitors and their descendents; i.e., genetic inheritance from fathers and mothers to their children. To establish this correspondence, one should obtain the genetic profiles of direct relatives. The genetic profile is a unique combination of the variants of the markers inherited from the parents, half from the mother and half from the father. The modern amplification technique using the PCR process allows us to obtain DNA from the cells of living tissues as well as from tissues of the deceased, including from those killed by exposure to extreme temperatures.

The scientific community has used three methods to demonstrate the ability to establish parentage with DNA:

1. Using markers called microsatellites in nuclear DNA from the genome of the nucleus of the cell, which represent the genetic profile of an individual;
2. With markers that are found exclusively in the DNA of the male sex chromosome and which are inherited by sons; and
3. Comparison of the sequence of regions of mitochondrial DNA, which is transmitted only through the maternal line, i.e., between a mother and her children, and among siblings through the mother.

The success of obtaining the profiles in tissues of dead bodies depends on how well the DNA is preserved. When tissue samples are very old the probability of success is greater when using mitochondrial DNA. In cases of burned remains, international reports indicate an average success rate of 50 percent in obtaining profiles.

Accepting cases, managing evidence, and maintaining chain of custody in DNA typing

The aim of these procedures is to guarantee that the chain of custody of evidence is maintained; to protect evidence against loss, deterioration, or detrimental changes; and to provide the necessary logistics to process a large number of samples.

Accepting cases

Decisions about accepting cases for DNA analysis depend on the proper administration of limited resources. Basically, the DNA laboratory is one of a variety of services used for identifying individuals, and DNA analysis should be authorized only when identification cannot be made using information provided by other resources. However, where DNA analysis might be required, samples should be obtained before evidence is handled, and they should be maintained as latent evidence, properly stored and safeguarded. This requires the formation of a regional network that can manage samples, and where similar conditions exist for DNA analysis in the network's different laboratories. The regional network's operational plans should include a standing arrangement for the exchange of biologists and geneticists so that a team of specialists can be mobilized to deal with massive numbers of cases. The network also should manage databases pertaining to the region's population.

Collecting samples for DNA analysis

The potential samples should meet basic standards if they are to be processed as latent evidence by a laboratory.

For forensic identification cases of individuals that either are not identified or are newborns, the first criterion to consider is the need to identify the individual, and hence, to transfer the corpse to petitioning families once the usual identification tests are exhausted. It should be understood that DNA testing is not a routine matter since it requires a long, labor-intensive, and costly procedure.

The person legally responsible for the analysis, that is the corresponding authority or the medicolegal expert, should decide, based on the guidelines described above, whether the sample to be taken will be processed as latent evidence. It is imperative that the appropriate authorities and experts take responsibility for maintaining the chain of custody for the evidence.

As part of the chain of custody, the appropriate authority or medicolegal expert should not only verify the validity of the corresponding sample, but guard against contamination or mixing samples being processed at the time (cross-contamination of samples), or contamination with material from the experts or others. Individual envelopes containing each sample should be stamped, sealed, and sent to the laboratory; the shipping documents should specify the envelope contents (type of samples) with the code of the sample. This code should also be written on the outside of the envelope so that it is easy to read. The shipping documents should be accompanied

by a sealed envelope containing a copy of the report that accompanies the samples, so that storage and custody for the sample can be prepared.

Priority criteria

The priority level of a case is determined by judicial authorities (criminal or civil judge, prosecutor, etc.) based on the following criteria:

- The evidentiary or investigative value provided by the results of DNA analysis (i.e., the corresponding authority accepts it or not as proof). The decision should be taken with prior consultation with the DNA laboratory, the immediate supervisor, the investigator responsible for the case, and a representative of the prosecutor's office;
- The probability (proposed by the DNA laboratory) that the results of the analysis will provide meaningful information in a reasonable amount of time;
- The deadlines established by the courts or other legal authorities;
- The order in which evidence is received.

Personnel responsible for collecting samples

Personnel with appropriate training, technical skill, and experience should collect the samples. The collection phase will define the quality of the analysis and permit better results in the allotted time. The regional network should have the resources to keep personnel up-to-date by carrying out exercises in the context of disaster plans.

Precautions during collection and dispatch of samples to the laboratory

When samples for analysis and reference samples are collected, a series of precautions should be followed to protect the personnel collecting the sample as well as to protect the sample itself. The sample can be affected if the process is not secure.

Protection of personnel

When handling human biological materials, one must assume that they contain dangerous pathogens (HIV, hepatitis, tuberculosis, meningitis, etc.) and be a possible source of infection. For this reason the universal precautions outlined below should be followed:

- Prevent, at all times, direct contact by the worker with the sample, using gloves, masks, gowns, or other protective clothing;
- Prohibit the consumption of food, drink, and tobacco products while handling the sample;
- Maximize asepsis and use disposable materials whenever possible. Once sample collection is complete, place all used disposable materials in containers for biological waste, and follow standards for disposal of biological waste;
- Recommend vaccination for personnel in contact with samples;

- When sample collection takes place in the autopsy station, extreme precautions should be taken.

Protection of samples

Many processes can affect the integrity of a sample and, therefore, the possibility of obtaining a genetic profile from the biological vestiges existing in the sample. In some cases these processes are inherent in the sample, and others can occur when collection and shipment of the samples to the laboratory are done incorrectly. These processes include:

- **Contamination by human biological material.** This occurs when human biological material is deposited at the site of the event or in the corpse following the event. It can be caused by onlookers, family members, or persons involved in the investigation who, accidentally or out of ignorance, contaminate the sample. This occurs frequently when minimal precautions when collecting evidence are overlooked or packaging is defective.
- **Contamination or loss during transfer of biological evidence.** This occurs, usually accidentally, during the transfer of evidence from one site to another and can result in the contamination or loss of a sample. It happens most frequently when hair samples are moved.
- **Microbiological contamination.** This type of contamination occurs when microorganisms develop, possibly as a result of humidity or high temperatures. Normally the microorganisms grow or proliferate because of defects in packaging or storage prior to sending the samples to a laboratory.
- **Chemical contamination.** This makes it difficult to amplify and extract DNA. It occurs when samples are immersed in preservatives such as formalin or when chemicals have been used in previous tests (for example, fingerprinting), thereby compromising DNA analysis.

Basic precautions

The contamination described above can be avoided or minimized if the following basic precautions are observed:

1. Isolate and secure, as quickly as possible, the scene of the event. Biological evidence should be the first evidence collected unless circumstances prohibit it;
2. Use clean gloves and change them frequently, especially when handling biological evidence likely to come from different sources;
3. Avoid speaking or sneezing on the samples. Use a mask;
4. Wear a gown or other protective clothing;
5. Use disposable instruments, and when possible use them only once, or clean them thoroughly between picking up each biological sample;
6. Do not add chemicals to preserve the samples;

7. Pack each sample separately. Whenever possible pack the samples in paper bags or cardboard boxes. Avoid using plastic containers;
8. Once the samples have been collected, throw used disposables (gloves, points, papers) in bags or containers for biological waste. Standards for disposal of biological waste should be followed.

Systems for packing and preserving samples

It is imperative to correctly preserve the samples from the moment they are collected until they arrive at a laboratory since the DNA in biological evidence—especially in wet and liquid samples—can begin to degrade within a few hours. Accordingly, proper packaging is very important and liquid evidence, soft tissues, organs, and wet evidence (if for some reason it can not be dried) should be kept refrigerated, including during shipping.

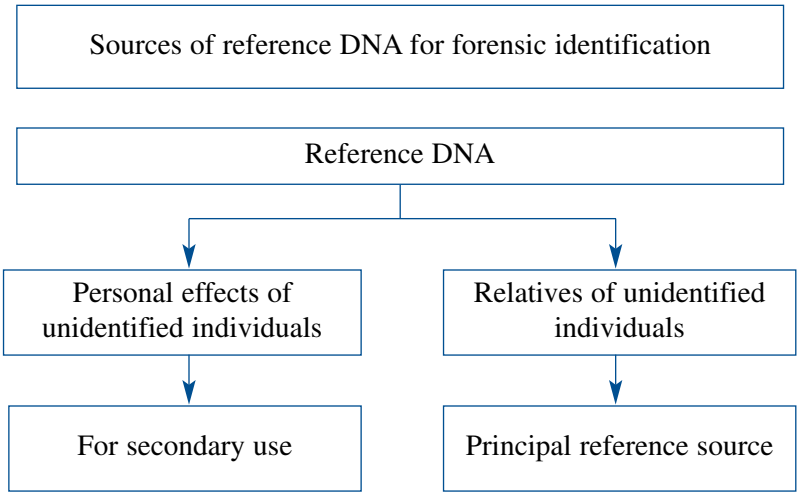
It is also very important to correctly identify and seal all receptacles (e.g., tubes, bags, boxes, etc.) with tape thereby guaranteeing the authenticity and integrity of the samples. Recommended packing and shipping procedures are outlined below:

1. **Identification of the samples.** There should be enough space on all of the receptacles to identify the samples and to write the following:
   - Reference number of the sample;
   - Type of sample;
   - Ownership of sample, and location.
2. **Chain of custody.** There also should be a space dedicated to the chain of custody with the name and signature of the person who collected the evidence, and the date and hour of collection.
3. **Packaging.** Packaging for samples or remains that should be sent to the laboratory are described below:
   - Jars or receptacles with liquid evidence, organs, soft tissue, etc. These receptacles should have screw-on lids or airtight closures; they should already have been sealed with tape and correctly identified; and should be kept refrigerated and sent to the laboratory under refrigeration as soon as possible.
   - Dry, sterile swabs. Swabs used to collect samples will be packed in small, cardboard boxes commercially designed for this purpose. This type of box protects the swabs and allows them to completely dry out. Once identified, they will be sealed with tape and sent without refrigeration to the laboratory. If it is not possible to obtain specially designed boxes, once the swabs have been used to collect the biological specimen they should be identified and numbered, placed in a protected area, and allowed to dry completely at room temperature before being placed in a shipping container. Once dry, the swabs can be placed in a correctly identified container, sealed with tape, and sent to the laboratory.
   - Samples with dry stains. Each sample is placed on top of paper (to avoid losing biological evidence such as hairs, scabs, etc.) that will be folded and

placed in a paper bag, sealed with tape, and correctly identified. This should be sent to the laboratory without refrigeration.

- Hairs, scabs or skin, nails, etc. This kind of material should be collected in small pieces of paper that will be carefully folded and put in a paper bag, sealed with tape, and correctly identified. This should be sent to the laboratory without refrigeration.
- Bones and teeth. These should be placed in paper bags and cardboard boxes that are sealed with tape and correctly identified. They can be sent to the laboratory without refrigeration. If tissue is still attached to bones, airtight, plastic receptacles should be used. These receptacles should be sealed with tape, correctly identified, refrigerated, and sent to the laboratory as soon as possible.

Collection of reference samples



Collection of reference samples from living subjects requires legal authorization and informed consent given by the person providing the sample. A document authorizing collection of the sample for genetic analysis for the purpose of identification should be signed. In the case of minors or mentally disabled persons, there should be parental or custodial consent in addition to legal authorization.

Conclusive samples from living subjects

Blood. Blood is the classic, conclusive sample used for obtaining DNA. If a person has received a blood transfusion in a period less than three months prior to sampling it is advisable to use buccal cells or hair follicles as reference samples, since it is possible to detect DNA from the provider of the blood, at least in a short period after transfusion. Blood can be obtained by venous or capillary puncture.

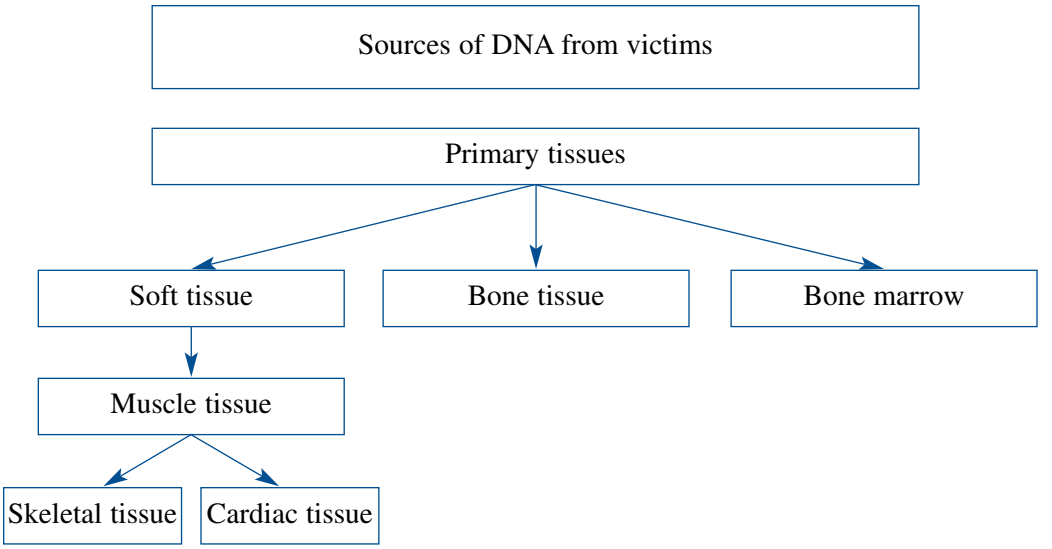
Buccal epithelial cells. These cells are collected from the inside of the subject's cheeks, using sterile, dry swabs. Two samples are taken: one swab is rubbed on the

inside of the left cheek, and another swab is used on the right cheek. The swabs should be identified and left to dry at room temperature in a protected area. They must not be placed in a container until they are completely dry since the bacteria in saliva proliferate rapidly in moist conditions and will degrade DNA.

Using the small conical brushes or swabs typically used for endocervical samples is appropriate for buccal cell samples, particularly since they dry easily. The sample should be taken at least one hour after the subject has eaten to avoid the presence of any food in the sample, or the subject should rinse his or her mouth thoroughly before the sample is taken.

Hair follicles. Between 10 and 15 hairs with roots should be pulled from the subject.

Conclusive samples in dead bodies



Conclusive samples in well-preserved bodies

Post mortem blood. A sample of about 10 ml of blood should be drawn into a tube containing an anticoagulant (EDTA type). If blood is needed for other analysis, additional samples should be collected.

Skeletal muscle. Select two skeletal muscle fragments (weighing about 10 g and approximately 2 cm wide) from the best preserved area of the body, and place them in a plastic container that has a wide mouth and screw-on lid. This type of tissue is preferable because along with cardiac muscle, it is the most resistant to decomposition.

Teeth. If there are doubts about the preservation of the corpse, it is advisable to extract four teeth, preferably molars, and save them so that exhumation of the body for identification purposes can be avoided. Prior to the extraction, a dental chart should be completed.

Conclusive samples in charred corpses

Despite the external appearance, the stability of DNA at high temperatures allows genetic analysis in corpses where charring is not complete by using fragments of skeletal muscle from deep regions of the body, and from semi-solid blood that remains inside cardiac cavities. If charring is total, it is advisable to contact the laboratory for an evaluation of the available samples and their condition to determine which would be most appropriate for analysis.

Conclusive samples in decomposed or skeletonized corpses

Bones. Remaining decomposed tissue should be removed from the bone, and a long bone, preferably the femur, should be used. If it is not possible to obtain this sample, the laboratory should evaluate available samples and their condition to determine which would be most appropriate for analysis.

Teeth. After a dental chart has been completed, select at least four teeth, molars where possible. The samples should not have been damaged or subjected to endodontia.

Conclusive samples in embalmed corpses

In embalmed corpses (those preserved artificially using preservatives such as formalin), DNA undergoes degradation that in most cases makes analysis very difficult. To select the most appropriate samples it is advisable to contact the laboratory that will carry out the analysis so they can evaluate the best samples in relation to the molecular biological techniques they will use, the type of substances used for embalming, and the age of the corpse, among other factors.

Other reference samples from the deceased

When it is not possible to exhume a body to obtain conclusive samples, or when there are no living relatives available to assist in the investigation, we can use other strategies, such as:

- Analysis of biological remains of the deceased found in hospitals. It is possible to study blood samples, biopsies preserved in paraffin, histological preparations, etc., of the deceased that exist in hospitals. It is not advisable to analyze tissues kept in formalin since this substance modifies DNA, making analysis difficult if not impossible.
- Analysis of biological remains of the deceased present in the home environment. Items that might have biological traces of the deceased, such as envelopes that might have saliva traces on the flap and seal, razors, combs and hairbrushes, etc., can be analyzed. This type of sample should be authenticated through genetic analysis of relatives, since samples may have been provided by family members who are involved in the judicial process. Once all usable biological material has been removed from the evidence, it can be stored at room temperature.

Disposition of the evidence

a) The analyst should ensure, to the extent possible, that enough of the sample remains to carry out new analyses if required. In cases in which all of the evidence has to be used to obtain interpretable results, the party soliciting the study should be consulted to ensure that they have considered legal implications of destroying the sample.

b) Once the analysis has been completed, the item of evidence should be returned in the original packaging (including the original labels), and properly sealed. The returned evidence should include clear storage instructions, and a certificate should be issued that states it is latent evidence.

c) The analyst who is responsible for repacking and resealing the evidence should note the respective contents on the return form. The person responsible for sending the package is responsible for written tracking reports of the shipment.

d) The DNA samples, electropherograms, and original results of the study will remain in the custody of the DNA laboratory. If the sample must be transferred to another laboratory, record of the transfer should be noted on the form included in the case file.

In this section we have touched on the main elements of forensic DNA studies used for identification in disasters. The bibliography at the end of this chapter lists important references that expand on the material presented here. Because it is a complex topic, it is also advisable to seek the services of a specialist in DNA analysis should any doubts arise.

FINAL DISPOSAL OF CORPSES

The final disposal of corpses can be done by burial or interment, which is almost universally practiced. In many countries, though, cremation is becoming more prevalent.

It might be necessary to preserve the body until it can be taken to the vigil or public viewing site or finally disposed of. For this reason, preservation is an important issue in the management of massive fatalities in disaster situations.

A variety of methods can be used to preserve the remains of victims, depending on the condition in which corpses are found. Traditionally the following methods are used:

- *Low temperatures:* The remains are kept in containers that are refrigerated with ice or other systems;
- *Chemical processes:* Substances are injected intravenously or placed or injected into the cavities or other parts of the corpse;
- *Immersion in liquids*;
- *Burial*.

Low temperatures

Maintaining a body at low temperatures is an ancient method of preservation. It can be achieved by using cold areas or rooms to maintain or freeze the remains, by using ice to maintain low temperatures (dry ice is usually recommended), or through any process that balances temperature and attains the desired result.

Since the time needed to complete medicolegal work will vary, it is vital to control the temperatures at which human remains are kept. This is important when using refrigerated chambers, especially facilities such as meat packing plants, boats, and refrigerated trucks or containers.

For example, freezing human remains can hinder the examination process. Freezing causes tissues to dehydrate which changes their color; this can have a negative impact on the interpretation of injuries, as well as on attempts at visual recognition by family members. Rapid freezing of bodies can cause post-mortem injury, including cranial fracture. Handling bodies when they are frozen can also cause fracture, which will negatively influence the investigation and make the medicolegal interpretation of the examination results difficult. The placement of one body on top of another in freezing temperatures can distort the faces of the victims, a condition which is difficult to reverse. Also, the process of freezing and thawing can accelerate decomposition of the remains.

Chemical processes

Using chemicals to process human remains has been known since ancient times, as can be seen by the famous Egyptian mummies and others discovered in tombs during archaeological excavations.

Although the injection of chemicals, especially formalin solutions, into blood vessels has been the most common method, similar results can be obtained using other solutions as well as by placing substances inside cavities or on the outside of bodies or body fragments.

When the integrity of a corpse is compromised, i.e., it is decomposed or in fragments, injection of chemicals is not possible. Other methods can be used to prepare the body or body parts in these situations, including the use of solid preservatives and proper wrapping of the remains. One method, which is explained in more detail in the next section, involves applying a substance to the remains that can prevent or interrupt the process of decomposition, eliminating or reducing disagreeable odors, and preventing fluids from leaking from the body during transport or the vigil. We have used powdered formaldehyde and powdered calcium hydroxide as well. After these substances are applied, the body or fragments are wrapped in several nylon or plastic bags and sealed completely with adhesive tape. This should only be done after all of the necessary medicolegal processes involved in identification and determination of the cause and circumstances of death have been completed.

Embalming

Embalming, also known as "artificial mummification," is one procedure that can be used on the dead body. It is an ancient technique that has been maintained over centuries and similar practices continue today. Embalming is addressed in the health legislation of many countries depending on their social, health, and cultural characteristics, and as such is of historical, religious, health, and social interest. The technique requires knowledge of anatomy and chemistry and the personnel carrying out the procedure must have specialized training.

The earliest mummification attempts in Egypt date to about 3200 B.C., and they probably began to mummify the dead intentionally, using embalming techniques, around 2600 B.C. This was not only an Egyptian practice. It is known to have been done by Arabs, Jews, Chinese, and Incas, who used balm, which is a natural sap, and aromatic substances, hence the term "embalm." Present day disinfectant fluids have replaced these balms.

Some authors define embalming simply as the preparation of a dead body for preservation, while others make a distinction between transitory preservation and body preparation. In general, embalming is the procedure used to preserve a body for more than 72 hours after death; transitory preservation is meant to maintain the body in an acceptable state for 24 to 72 hours after death. Preparation of the body is understood as a more complex procedure that is carried out on a corpse found in some stage of decomposition and that attempts to minimize the effects of and slow down decomposition.

Regulations about embalming differ in each country. Depending on the reasons for requesting the procedure, solicitants might be family or associates of the deceased, representatives of diplomatic missions or foreign institutions, government or state officials, or the responsible judicial or health authorities. Authorization to perform the procedure is given to mortuary services, medicolegal institutes, and other qualified services as stipulated in local laws.

There are different motives for embalming, among which we should note the repatriation or transfer of a corpse out of a country, preparation of an unidentified corpse for viewing, scientific or teaching purposes, state or government interests, and for other objectives as determined by the corresponding health or judicial authorities.

Embalming techniques have evolved throughout history. Initially, three basic types of were done depending on the status or class of the deceased, each method using different types of materials. The most complete and labor intensive basically involved placing aromatic essences in the cavities of the body and covering the body in salts. First, an iron hook was used to extract the brain through the nostrils, and fragrant infusions were injected through the openings. The intestines were removed through a small incision in the torso, washed in palm wine, and infused with aromatic substances. The body cavities were then filled with myrrh, cassia, and other extracts. The incisions were closed and the body was covered with natrum (a compound of sodium carbonate and sodium bicarbonate). Seventy days later the body was washed, wrapped with strips of linen cloth that had been smeared with resins, and finally placed in a wooden coffin that was carved to resemble the human figure.

While the process has changed over the centuries, the principles have remained the same: i.e., the substitution of blood and fluids with preservatives, especially liquid disinfectants, which depending on the case are injected into blood vessels or into body cavities. Today, embalming can be done on dead bodies whether or not they have undergone autopsy. We should point out that in the 1970s embalming was practically obligatory in certain countries.

In the following section we will give further details about the most commonly used techniques according to the condition of the body.

Requirements for embalming or body preparation

Among the most important requirements to take into account for these procedures are:

- Trained technical personnel;
- Appropriate equipment and instruments;
- Preservation materials; and
- Adequate working area.

The personnel responsible for embalming should have basic knowledge of human anatomy and chemistry which can be obtained through academic training; there is also international certification in this discipline. Ideally, certified and highly qualified personnel who are dedicated to this type of work should assist in emergency situations.

If this is not possible, there should be personnel who have basic knowledge and training and who are supervised by competent specialists.

Instruments and materials for corpse preparation are not very different from those used for surgery and in autopsy settings. At a minimum, they should include:

- Straight and curved scissors
- Scalpel or bistoury
- Dissecting forceps
- Grooved director
- Trocar (different sizes)
- Suture thread and needles
- Filling material
- Embalming fluids
- Plastic or nylon bags
- Protective clothing and shoes (surgical gowns, caps, masks, etc.).

The area used for embalming or body preparation should meet certain minimal criteria appropriate for a variety of situations, and taking into account the following principles:

- Adequate privacy and lighting;
- Placement of the remains on an autopsy table or comparable surface;

- Availability of water, preferably an abundant amount of running water;
- Good natural ventilation, or if that is not possible, exhaust fans. Air conditioning as the sole means of air circulation is not recommended because of the toxicity of gas fumes associated with preservative substances, especially formalin;
- Smooth and polished floors and walls that facilitate cleaning and hygiene. In field conditions the area should be continually cleaned, even in the case of dirt flooring;
- Adequate control of the disposal of liquids and of biological matter extracted from the body.

Embalming techniques without autopsy

Any of the techniques described below require skills acquired through special training, and merit a course dedicated to the subject. However, we will summarize the steps of the process here.

The body should be placed in a supine position with the extremities extended. An incision is made inside the upper left arm and muscle mass in the arm is separated until the brachial artery is found and lifted. Two ligatures, 5 cm apart, are passed under the artery. A transverse incision is made and a trocar is inserted in the artery pointing to the lower part of the body, as the upper ligature is tightened. This ligature is then loosened, the direction of the trocar is changed, and the ligature is tightened again, permanently. Once insertion of preservative liquid is complete, the incision is sutured.

In the cranial cavity solution can be injected through the carotid arteries or by inserting a trocar through the nose by way of the cribriform plate of the ethmoid bone.

Embalming technique for body fragments

Fragmentation of bodies can be very extensive in events such as aviation disasters, characterized by serious damage to blood vessels and other tissues. In such cases, an attempt should first be made to reconstruct the fragments using sutures, especially of the major vessels, followed by injecting preservative liquids.

Alternatives should be sought for preparing body parts or fragments where major damage has occurred to tissues as a result of crushing, burns, and other causes. This is especially important when it is necessary to transfer the bodies and comply with established health regulations. One proposal is to preserve the fragments with solids rather than the liquids typically used. Powdered forms of calcium hydroxide (lime), zeolite, and formalin, among others, adhere to the surface of the fragments and can be placed inside cavities, in small slits and lacerations, etc. Application of these substances is followed by placing the fragments in plastic bags, which are then tightly wrapped in adhesive tape. These bags are relatively airtight and generally prevent leakage of body fluids that occurs during handling, which helps to maintain a level of hygiene as well as limiting foul odors during handling.

Embalming bodies of newborns and fetuses

When embalming a fetus, it is advisable to inject preservative fluid though the umbilical vein. The vein is located in the umbilical cord and the fluid is introduced by gravity or by using equipment that pumps the preservative (approximately 1 liter) into the fetus.

The embalming technique used for a newborn is similar to that used for a fetus. However, we can also recommend a technique similar to that used in adults. Fluid is introduced through the brachial, axillary, or femoral artery and cavities are filled with material soaked in preservatives. The only difference is the volume of liquid preservative used: depending on body surface, it would be between 1 and 2 liters for a newborn.

Transitory preservation of a dead body

Transitory preservation of a dead body can take place, as in embalming, whether or not an autopsy has been performed. When an autopsy has not been performed, the arterial route is used (as for embalming), with the difference that the fluid has a lower concentration of formalin and the volume is much less, varying between 2 and 3 liters for adult bodies.

When autopsy has been performed, after the cavities are filled, transitory preservation can be successfully done by soaking the fill material in preservation fluids or including powders or solid preservation materials as part of the fill material.

Techniques for dead body preparation

Dead body preparation includes the work done on a body or body parts with the aim of minimizing the effects of putrefaction and preventing its progression.

In general, it is based on the same techniques used for embalming, although prior to these it might be necessary to expel gases or eliminate putrid matter. At times, this can lead to forced skeletal or mechanical reduction, which leads to the elimination of the mass of putrilage, leaving the remains in an almost total skeletal phase, even though tissue remains adhered to the bone surface, especially the joints.

Gases can be expelled by selective puncture in affected areas, especially in the area of the perineum, male scrotal sacs, and the female mammary folds, among other sites. A certain amount of gas can be released to decrease facial swelling by making incisions on the interior of the cheeks, and pressing the cheeks with gauze to attempt to expel gases.

In these cases it is advisable to place the remains in plastic bags with preservatives or antiseptics, and wrapping them tightly with adhesive tape as was described for the preparation of body fragments.

There are many other techniques, depending on the case, and specialized texts should be consulted.

Aesthetic reconstruction of features

Damage caused to the human body by disasters is difficult to conceive, and it varies widely. Defining reconstruction methods for every case is impossible, so we will only a mention a few of the more common situations that might demand our involvement.

Suture of each of the wounds and any incisions made is an essential measure. Very strong glues that dry instantly and are readily available are recommended for this process.

Special reconstruction techniques can be used to attempt to restore facial features. To restore some of the features of the eye that have been lost, almost always due to trauma, compresses moistened with water are placed on the eyes for 30 minutes to 1 hour, and then glycerin or physiologic saline solution is injected in the space behind the eyeball, restoring its spherical shape. When the eyeballs have completely lost their shape, it is necessary to resort to prostheses, or at least fill the eye sockets, especially if the body must be prepared for visual recognition. In these and other cases, the eyelids can be closed with small sutures on the top and bottom lids. The mouth can be closed using sutures in both lips made from the inside.

Facial swelling might occur because of gases. As mentioned earlier, incisions can be made on the inside of the cheeks and pressure applied to the cheeks with gauze to attempt to expel gases, thereby recovering a more normal appearance of facial features.

The use of cosmetics, prostheses, wigs, and other materials that favor the aesthetic, above all of facial features, should be adapted to the case in question. It is important to take into account the age, sex, race, and other distinguishing features of the subject, as well as general customs in the country.

Preservative materials

A variety of substances for preservation are recommended by different specialists. In remote times, the Egyptians, Arabs, and Chinese used balm and resins (natrum, myrrh, and tars) which have been replaced over time with alcohol, glycerine, white arsenic, sodium chloride, potassium nitrate, and zinc chloride, among others.

Many recommend that the preservative solution for injection into dead bodies should be made from a basic solution of 40% formol and carbolic acid, while others use a combination of formol with alcohol and glycerine (for each liter of solution of formol, one half liter of alcohol is used). Most recommend the use of formol, starting with 10% concentrations, together with glycerine; if formol is not available, 20% zinc chloride in alcohol or glycerine can be used.

One recommended formula has the following ingredients:

- 30% formol, 300 ml;
- 80 proof ethanol, 700 ml;
- Glacial acetic acid, 5 ml; and
- Phenol, 20 gm

This is injected in a quantity that approximates the blood volume of the subject when alive.

Immersion in liquid

While not a true form of preservation (except as used in anatomy classes in most schools of medicine), this is an option that might be considered when there is an evident delay in burial for technical or other reasons.

It is well known that putrefaction in submerged bodies is slower than in bodies exposed to air, so it is possible to immerse bodies in tanks, pools, or other receptacles when there is no other option for temporary preservation.

Burial

Based on the same principles outlined above, placement of bodies below ground can facilitate temporary preservation. Temporary burials can be justified in disaster situations until conditions allow for the transfer of the remains from the disaster site to their final destination.

In cases of temporary burial, the use of documentation and markers of the burial site should be as strictly followed as for final burial in officially established cemeteries.

We hope that with the information provided in this chapter, although in the most difficult of working conditions and without the presence of true experts, a professional with basic training can deal with the diverse and complex tasks required for managing massive fatalities that can occur in major disasters.

BIBLIOGRAPHY

Alcocer J, Alva Rodríguez M. *Medicina legal. Conceptos básicos*., Mexico: Limusa, 1993.

Alvarado Morán G A. *Medicina jurídica.* First edition. El Salvador, 1987.

Basile AA. *Fundamentos de medicina legal*. Buenos Aires: Ateneo, 2001.

Carrillo A. *Lecciones de medicina forense y toxicología*. Guatemala: Editorial Universitaria, 1993.

Castro y Bachiller R. *Suplemento del tratado de medicina legal*. Havana (no date).

Comas J. *Manual de antropología física*. Mexico: UNAM, 1983.

Fernández Chirino E. *Estomatología forense*. Lima: Buenaventura, 1994.

Fernández Pereira J. *Criminalística*. Havana: Editora Universitaria, 1991.

Giraldo C A. *Medicina forense*. Medellín: Señal Editora, 1998.

Gisbert Calabuig JA. *Medicina legal y toxicología*. Fifth edition. Barcelona: Masson, 1998.

González Pérez J et al. *Manejo masivo de víctimas fatales en situaciones de desastres*. Havana: Editorial de Ciencias Médicas, 1995.

Huerta MM. *Medicina legal*. Fourth edition. Sucre: Tupac katari,1992.

Lancís y Sánchez F et al. *Medicina legal*. Havana: Editorial de Ciencias Médicas, 1999.

Llorente Acosta JA, Lorente Acosta M. *El ADN y la identificación en la investigación criminal y en la paternidad biológica*. Granada: Comares, 2001.

Moreno González R. *Manual de introducción a la criminalística.* Seventh edition. Mexico: Editorial Porrua, 1993.

International Civil Aviation Organization (ICAO). *Manual of Aircraft Accident Investigation. Investigation of Human Factors*. Fourth edition. ICAO, 1970.

_____. *Convention on International Civil Aviation*. Fifth edition. ICAO, 1975.

Pan American Health Organization. *Emergency Health Mangement after Natural Disaster.* Scientific Publication No. 407. Washington, D.C.: PAHO, 1981.

_____. *Emergency Vector Control after Natural Disasters*. Scientific Publication No. 419. Washington, D.C.: PAHO, 1982.

_____. *Memorias de la IV reunión de evaluación del programa de preparativos de salud para casos de desastres*. Panama, 1990.

Oviedo SF. *Medicina legal*.Quito: Ediciones Abya-Yala, Quito 1997.

Paz Soldan R. *Medicina legal*. La Paz: Editorial Juventud, 1991.

Polson CJ, Gee DJ. *The essentials of forensic medicine*. Third edition. Toronto: Pergamon Press, 1973.

Pospisil M. *Manual de prácticas de antropología física*. Havana: Editorial del Consejo Nacional de Universidades, 1965.

Ramírez Covarrubias G. *Medicina legal mexicana*. Second edition. Mexico: Editorial 2000, 1998.

Reimann W, Prokop O. V*ademecum de medicina legal*. Havana: Editorial Científico Técnica, 1980.

Rivas Sousa M. *Medicina forense*. Guadalajara: Ediciones Cuellar, 2001.

Robbins. *Patología estructural y funcional*. Fifth edition. Madrid: McGraw-Hill-Interamericana, 1998.

Rojas N. *Medicina legal*. Seventh edition. Buenos Aires: Ateneo, 1959.

Saccomanno L et al. Identificación de víctimas fatales en los desastres en masa. Creación de un equipo medicolegal. *Boletín de Medicina Forense Argentina*, 1990;10(27).

Colombia. Secretaría de Gobierno y Apoyo Ciudadano. *Manual de procedimientos en criminalística y medicina legal*. Medellín: Imprenta Departamental de Antioquia, 1999.

Simonin C. *Medicina legal judicial*. Reprint of second Spanish edition. Barcelona: Jims, 1973.

Tedeschi CG. *Forensic medicine*. Philadelphia: Saunders, 1977.

Teke A. *Medicina legal*. Santiago de Chile: Mediterráneo, 1993.

Vanegas González AL. *Huellas forenses. Manual de pautas y procedimientos en medicina forense*. First edition. Medellín: Biblioteca Jurídica, 2000.

Vargas Alvarado E. *Medicina legal*. Mexico: Trillas, 1996.

Veiga de Carvalho H et al. *Compendio de medicina legal*. Second edition. Sao Paulo: Saraiva, 1992.

SPECIAL BIBLIOGRAPHY ON DNA

Alonso A, Andelinovic S, Martín P, Sutlovic D, Erceg I, Huffine E, Fernández de Simón L, Albarrán C, Definis-Gojanovic M, Fernández-Rodriguez A, García P, Drmic I, Rezic B, Kuret S, Sancho M, Primorac D. "DNA typing from skeletal remains: evaluation of multiplex and megaplex STR systems on DNA isolated from bone and teeth samples." *Croatian Med J* 2001;42:260-6.

Ayres KL. "Relatedness in subdivided populations." *Forensic Sci Int* 2000;114:107-15.

Balding DJ, Nichols RA. "A method for quantifying differentiation between populations at multi-allelic loci and its implications for investigating identity and paternity." *Genetica* 1995; 96:3-12.

Bramley RK. *Quality assurance in DNA profiling*. First International DNA Users Conference, 1999.

Budowle B, Monson KL, Chakraborty R. "Estimating minimum allele frequencies for DNA profile frequency estimates for PCR-based loci." *Int J Legal Med* 1996;108:173-6.

Chakraborty R, Jin L, Zhong Y. "Paternity evaluation in cases lacking a mother and nondetectable alleles." *Int J Legal Med* 1994;107:127-31.

Clayton TM, Whitaker JP, Fisher DL, Lee DA, Holland MM, Weedn VW, Maguire CN, DiZinno JA, Kimponton CP, Gill P. "Further validation of a quadruplex SR DNA typing system: a collaborative effort to identify victims of a mass disaster." *Forensic Sci Int* 1995;76:17-25.

Dawid AP, Mortera J, Pascali VL. "Non-fatherhood or mutation? A probabilistic approach to parental exclusion in paternity testing." *Forensic Sci Int* 2001;124:55-61.

Essen- Môller E. *Mitt Anthropol Ges* 1938;68:9-53.

Evett IW, Weir BS. *Interpreting DNA evidence*. Sinauer, MA, 1998.

Fisher DL, Holland MM, Mitchell L, Sledzik PS, Webb Wilcox A, Wadhams M, Weedn VW. "Extraction, evaluation, and amplification of DNA from decalcified and undecalcified United States Civil War bone." *J Forensic Sci* 1993;38:60-8.

Frank WE, Llewellyn BE. "A time course study on ST profiles derived from human bone, muscle and bone marrow." *J Forensic Sci* 1999;44:762-6.

Gabriel MN, Huffine EF, Ryan JH, Holland MM, Parson TJ. "Improved MtDNA sequence analysis of forensic remains using a "mini-primer set" amplification strategy." *J Forensic Sci* 2001;46:247-53.

Hoff-Olsen P, Mevag B, Staalstrom E, Hovde B, Egelend T, Olaisen B. "Extraction of DNA from decomposed human tissue. An evaluation of five extraction methods for short tandem repeat typing." *Forensic Sci Intl* 1999;105:171-83.

Holland MM, Fisher DL, Mitchell LG, Rodriquez WC, Canik JJ, Merril CR, Weedn VW. "Mitochondrial DNA sequence analysis of human skeletal remains: identification of remains from the Vietnam war." *J Forensic Sci* 1993;38:542-53.

Hummel K et al. *Biostatistical opinion of parentage*. Gustav Fisher Verlag; 1971.

Lee HC, Pagliaro EM, Berka KM, Folk NL, Anderson DT, Ruano G, Keith TP, Phipps P, Herrin GL, Jr, Garner DD, Gaensslen RE. "Genetic markers in human bone: I. Deoxyribonucleic acid (DNA) analysis." *J Forensic Sci* 1991;36:320-30.

Lee HS, Lee JW, Han GR, Hwang JJ. "Motherless case in paternity testing." *Forensic Sci Int* 2000;114:57-65.

Lewis PO, Zaykin D. Genetic data analysis: computer program for the analysis of allelic data. Version 1.0 (d16c); 2001. http://lewis.eeb.uconn.edu/lewishome/software.html.

Luque JA, Valverde JL." Índice de hermandad. II. Estudio y valoración mediante STR." *IV Jornadas de genética forense*. Spain; 1999.

Luque JA, Valverde JL. "Paternity evaluation in cases lacking a mother and nondetectable alleles." *Int J Legal Med* 1996;108:229.

Luque JA, Valverde JL. *VI Jornadas de genética forense*. Córdoba, Argentina, 2001.

Martin-de las Heras S, Valenzuela A, Villanueva E, Marques T, Exposito N, Bohoyo JM. "Methods for identification of 28 burn victims following a 1996 bus accident in Spain." *J Forensic Sci* 1999;44:428-31.

Melton T, Clifford S, Kayser M, Nasidze I, Batzer M, Stoneking M. "Diversity and heterogeneity in mitochondrial DNA of North American populations." *J Forensic Sci* 2001;46:46-52.

Moretti TR, Baumstark AL, Defenbaugh DA, Keys KM, Smerick JB, Budowle B. "Validation of short tandem repeats (STRs) for forensic usage: performance testing of fluorescent multiplex STR systems and analysis of authentic and simulated forensic samples." *J Forensic Sci* 2001;46:647-60.

Morling N, Allen RW, Carracedo A, Geada H, Guidet F, Hallenberg C, Martin W, Mayr WR, Olaisen B, Pascali VL, Schneider PM. "Paternity testing commission of the International Society of Forensic Genetics. Recommendations on genetic investigations in paternity cases." *Forensic Sci Int* 2002;129:148-57.

National Research Council. *The Evaluation of Forensic DNA Evidence*. Washington, D.C.:National Academic Press; 1996.

Perry WL, III, Bass WM, Riggsby WS, Sirotkin K. "The autodegradation of deoxyribonucleic acid (DNA) in human rib bone and its relationship to the time interval since death." *J Forensic Sci* 1988;33:144-53.

Primorac D, Andelinovic S, Definis-Gojanovic M, Drmic I, Rezic B, Baden MM, Kennedy MA, Schanfield MS, Skakel SB, Lee HC. "Identification of war victims from mass graves in Croatia, Bosnia, and Herzegovina by the use of standard forensic methods and DNA testing." *J Forensic Sci* 1996;41:891-4.

Rahman Z, Afroze T, Weir BS. "DNA typing results from two urban subpopulations of Pakistan." *J Forensic Sci* 2001;46:111-5.

Rankin DR, Narveson SD, Birkby WH, Lal J. "Restriction fragment length polymorphism (RFLP) analysis on DNA from human compact bone." *J Forensic Sci* 1996;41:40-6.

Riancho JA, Zarrabeitia MT. "PATCAN: a Windows-based software for paternity and sibling analyses." *Forensic Sci Int* 2002.

Rubocki RJ, Duffy KJ, Shepard KL, McCue BJ, Shepard SJ, Wisecarver JL. "Loss of heterozygosity detected in a short tandem repeat (STR) locus commonly used for human DNA identification." *J Forensic Sci* 2000;45:1087-9.

Silver H. "Probability of inclusion in paternity testing." *AABB* 1982.

Stone AC, Stoneking M. "Analysis of ancient DNA from a prehistoric Amerindian cemetery". *J Forensic Sci* 1999;44:153-9.

Stone AC, Starrs JE, Stoneking M. "Mitochondrial DNA analysis of the presumptive remains of Jesse James." *J Forensic Sci* 2001;46:173-6.

Sweet DJ, Sweet CHW. "DNA analysis of dental pulp to link incinerated remains of homicide victim to crime scene." *J Forensic Sci* 1995;40:310-4.

Thompson WC, Taroni F, Aitken CGG. "How the probability of a false positive affects the value of DNA evidence." *J Forensic Sc*i 2003;48:47-54.

Yamamoto T, Uchihi R, Kojima T, Nozawa H, Huang X-L, Tamaki K, Katsumata Y. "Maternal identification from skeletal remains of an infant kept by the alleged mother for 16 years with DNA typing." *J Forensic Sci* 1998;43:701-5.