

## Annexure 16:

# Guidelines for Dead Body Management and Victim Identification in CBRN Disasters

## References

Source:

*Guidelines for the Management and Identification of Deceased Victims in Chemical, Biological, Radiological and Nuclear (CBRN) disasters.*

*Review of Forensic Pathology 2011: 2, 94-107.*

*G. Ponsell, C. Fillon, and Y. Schuliar.*

## **Annexure 16: Guidelines for Dead Body Management and Victim Identification in CBRN Disasters**

*Summary – To respond to a CBRN disaster, such as an industrial accident or a terrorist attack, our country has specific plans to provide timely responses in terms of organization of rescue operations and care of the wounded. These plans are designed to optimize the protection of human life and address only briefly the management of dead bodies. But dead body management and victim identification are a necessary task. Indeed, victim identification is a legal obligation and a moral necessity. Victim identification in the wake of conventional disasters is a known and effective process, but what would happen in the event of a CBRN disaster? The handling of contaminated bodies poses a considerable risk not only to responders, but also and more broadly to the public and surrounding environment. In this article, we look at the dangers associated with contaminated bodies, and propose pre-identification decontamination procedures specific to each CBRN risk. We explain a victim identification exercise in a CBRN environment conducted by the Criminal Research Institute (Gendarmerie nationale). And lastly, we describe operational resources available to us today in the identification of CBRN victims.*

### Introduction

Natural and man-made disasters are inevitable occurrences that have become part of the life experience of mankind. Natural disasters (earthquakes, tsunamis) are unpredictable and therefore beyond our control. But we now live in a modern world where potential man-made disasters abound, whether it be due to increased air and air passenger traffic, ever-expanding industrial development and its inherent manufacture/use/transportation of hazardous materials or the threat of terrorism.

Terrorism has become an ever-present threat. In the wake of September 11, 2011, western society knows there are no limits to how far terrorists will go in the pursuit of their ideals. Special national plans (Secretariat General for National Defence and Security) have been developed in order to ensure the best possible response to all types of attacks, including those of a chemical, biological, radiological and nuclear nature (CBRN). These plans address all categories of CBRN incidents, whether they be the result of terrorist activity or accidental.

These plans, aimed at preserving human life, address only briefly the management of cadavers, and make no mention of victim identification.

Large-scale disasters of this nature, in addition to the obvious consequences, often result in mass casualties. In some cases, the degradation of corpses makes it impossible to visually identify victims with any certainty.

In today's world, victim identification is a moral necessity and a legal obligation. The legal response to the loss of a loved one will vary, based on whether the victim is a missing person or deceased. Families can begin to grieve only once death has been confirmed, and it helps if they have a body to lay to rest.

To manage dead bodies, you have to handle dead bodies. In a CBRN disaster, corpses are contaminated/infected by hazardous and often deadly agents.

The issue then becomes how to simultaneously identify victims, ensure the safety of responders and protect the public, not to mention conduct an investigation by identifying terrorists.

To begin, we will review the general principles of victim identification. We will then explain the dangers associated with the effects of CBRN agents in the management of dead bodies and propose appropriate decontamination procedures.

We will look at how France organizes victim identification operations, as well as specific CBRN resources available to us here. We will present a victim identification exercise conducted by Gendarmerie nationale members wearing CBRN protective gear. And lastly, we will look ahead to the future, with the development of imaging techniques and virtual autopsies.

## Victim identification [10, 6]

Identification is based on the comparison of and search for similarities and/or incompatibilities between post-mortem (PM) and ante-mortem (AM) data.

The process is threefold: compile an AM file, compile a PM file, then compare the data.

The AM file contains information provided by the relatives/loved ones of a missing person. In meetings with the latter, authorities are able to gather information on physical traits/clothing/medical conditions, collect familial DNA samples and obtain contact information for health practitioners. These health professionals (physicians, surgeons, dentists, etc.) will be able to provide medical/dental records containing vital AM reference data.

The PM file is established based on anatomical data retrieved from the body and samples taken from the victim.

Disasters are typically categorized as either open or closed. An open disaster is a major catastrophic event resulting in the deaths of a number of unknown individuals for whom no prior records or descriptive data are available. It is difficult to obtain information about the actual number of victims following such events. The list of victims is established as the investigation progresses, based on persons reported missing by family members and loved ones.

A closed disaster is a major catastrophic event resulting in the deaths of a number of individuals belonging to a fixed, identifiable group (e.g. plane crash with passenger list). As a rule, comparative AM data can be obtained more quickly in the case of closed disasters.

Combinations of these two forms are also conceivable, for example when a plane crash occurs in a residential area.

There are different ways to establish a victim's identity, which can be used on their own or in combination.

## Visual identification

Loved ones are sometimes able to identify corpses immediately after a disaster. Later, photographs of bodies can be shown to relatives/loved ones for identification purposes. With no scientific basis, this option is unreliable given the major psychological trauma of those attempting to make the identification. Visual identification can be helpful, but is insufficient on its own for the positive identification of victims and should therefore be avoided.

## Personal effects

The analysis of personal effects can help investigators establish the possible identity of victims. For instance, a piece of jewellery, article of clothing or piece of identification can make it possible to quickly establish a presumed identity. Subsequent scientific evidence in support of said identity is required.

## External exam

The forensic pathologist documents all physical features of the body (sex, age, height, build, skin/eye/hair colour, etc.), as well as special markings (scars, tattoos, moles, etc.).

## Fingerprints

The epidermis and dermis are fairly resistant to PM degradation. Forensic experts are able to use special skin restoration techniques, even in the case of advanced decomposition. Obviously, there are limits to what can be done with severely decayed/burnt human remains.

Fingerprints are reliable indicators of identity. Because they can be classified, fingerprints can be identified and registered systematically and thus, subsequently, retrieved easily for purposes of comparison. In the event of mass casualties (9/11 attacks, December 2004 tsunami), AM and PM fingerprints are cross-checked using an automated system.

Palm prints and footprints can also be used in victim identification.

## Internal exam

Ideally, a full autopsy is performed in an effort to identify the victim and determine the cause/circumstances of death. The forensic pathologist looks for surgical scars, prosthetic elements and possible medical conditions.

In female victims, the forensic pathologist checks for pregnancy, contraceptive devices or evidence of a hysterectomy.

Scars are dissected in search of medical devices (orthopedic, cardiac, digestive, esthetic, etc.).

## Odontology

The unique structures and traits of human teeth and jaws readily lend themselves to victim identification. And teeth are virtually indestructible over time.

In the event of a violent death (plane crash, explosion), bodies are subjected to considerable energies and fire. The teeth are well protected in the oral cavity and are able to withstand many external influences at, near or after the time of death. Teeth are the hardest and most resilient substances in the body, so as the body's soft tissues deteriorate, the dental characteristics that are so valuable for identification purposes remain accessible. This is especially true of treatments in the teeth, such as fillings and crowns. Even when crowns are destroyed, the maxillary bone protects the roots, which can provide important information.

A person's mouth and teeth can be a key source of information (anatomy, physiology, pathology, therapeutics). This data can then be compared to AM data contained in records provided by a victim's dentist.

## DNA

DNA analysis is the only way to match all body parts belonging to a human remain.

PM samples may be infectious if taken from bodies contaminated by potentially hazardous agents. Hence, there are special requirements regarding collection, labelling, transportation and any handling that must be observed. Samples must be processed at laboratories with a P3 classification.

It goes without saying that fingerprints, dental records, DNA analysis and medical data are of great use in positive victim identification, but of potentially equal importance is other information provided by anatomical features, tattoos, etc. Depending on the nature of the disaster, the condition of the body and available AM data, forensic experts will use the techniques best suited to the given situation.

The problem with the above-noted procedures is that CBRN corpses are contaminated by agents that pose a risk not only to responders, but also and more broadly to the public and surrounding environment.

### **RN risk**

A nuclear disaster would cause mass casualties and completely destabilize management operations.

Most victims would be killed by the explosion itself (blast, heat). Some would be irradiated, not contaminated, and others would be irradiated and contaminated by radioactive materials (dust or aerosol).

Today, this type of incident with a nuclear explosion is considered unlikely. A more probable threat would be an attack involving an explosion with the dispersion of radioactive materials (dirty bomb).

In such a scenario, people would be killed immediately by the aftermath of the explosion, their bodies covered with radioactive materials in the form of both dust and shrapnel.

Responders who handle human remains that are potentially radiologically contaminated are exposed to irradiation and contaminant transfer.

### **B risk**

Bioterrorism agents are categorized as follows by Atlanta's Centers for Disease Control (CDC). [2]

#### Category A:

- Anthrax (*Bacillus anthracis*)
- Botulism (*Clostridium botulinum* toxin)
- Plague (*Yersinia pestis*)
- Smallpox (*Variola major*)
- Tularemia (*Francisella tularensis*)
- Viral hemorrhagic fevers (filoviruses – e.g. Ebola, Marburg – and arenaviruses, e.g. Lassa, Machupo)

These agents pose the highest risk to national security because:

- > they can be easily disseminated or transmitted from person to person;
- > they result in high mortality rates and have the potential for major public health impact;
- > they might cause public panic and social disruption; and
- > there are few or no treatments.

#### Category B:

- Brucellosis (*Brucella* species)
- Epsilon toxin of *Clostridium perfringens*
- Food safety threats (e.g. *Salmonella* species, *Escherichia coli* 0157:H7, *Shigella*)
- Glanders (*Burkholderia mallei*)
- Melioidosis (*Burkholderia pseudomallei*)
- Psittacosis (*Chlamydia psittaci*)
- Q fever (*Coxiella burnetii*)

- Ricin toxin from *Ricinus communis* (castor beans)
- Staphylococcal enterotoxin B
- Typhus fever (*Rickettsia prowazekii*)
- Viral encephalitis (alphaviruses – e.g. Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis)
- Water safety threats (e.g. *Vibrio cholerae*, *Cryptosporidium parvum*)

These agents pose the second-highest risk because:

- > they are moderately easy to disseminate;
- > they result in moderate morbidity rates and low mortality rates; and
- > there are possible treatments.

Category C:

- Emerging infectious diseases such as Nipah virus and hantavirus

These emerging pathogens could be engineered for mass dissemination in the future because due to:

- > availability;
- > ease of production and dissemination; and
- > potential for high morbidity and mortality rates and major health impact.

There are two levels of risk with respect to deceased body management. The highest risk involves handling human remains contaminated and infected with highly contagious agents (smallpox, H5N1, plague). These agents can be easily disseminated among the population well beyond the primary contacts.

The second, lower risk involves handling bodies contaminated or infected with non-contagious (anthrax, tularemia) or non-toxic (ricin, saxitoxin, botulinum toxin) agents. It is vital that responders eliminate the risk of contaminant transfer (e.g. agent in powder form) and protect themselves against the risk of accidental blood exposure (ABE).

In addition to external contamination, the primary concern with B risks is internal contamination or infection of the body by bacteria/viruses.

The management of bodies contaminated (externally) solely with a B agent is unlikely (explosion of P3 or P4 lab, etc.).

In most cases, the risk is therefore infection of an organism by a B agent.

## C risk

People can be exposed to many different toxic chemicals, either accidentally (industrial accident) or intentionally (terrorist act).

For the purposes of deceased body management, only chemicals that are persistent in the environment (vesicants, nerve agents) pose a risk to responders.

After a few hours, gases (phosgene, hydrogen cyanide) are no longer present on a dead body. So other than proper ventilation, no specific precautions are necessary.

Below are the primary hazardous chemicals which pose a risk in the handling of dead bodies.

Blistering agents/Vesicants (mustards and lewisites)

- persistent in the environment for a long time
- irritate the respiratory tract (vapour)

- irritate the skin (liquid and vapour)

Nerve agents (sarin, soman, tabun, VX)

- persistent in the environment
- irritate the respiratory tract (vapour)
- irritate the skin (liquid)
- ranked from the most volatile to the most persistent
  - sarin
  - soman to thickened soman
  - tabun
  - VX

Choking agents (phosgene and diphosgene)

- non-persistent gaseous agents
- no risk to responders handling bodies after proper ventilation of the fatality zone

Blood agents (arsine, hydrogen cyanide, cyanogen chloride)

- volatile, non-persistent agents
- no risk to responders handling bodies after proper ventilation of the fatality zone

Incapacitating agents → non-lethal (LSD, BZ)

- powders
- easily eliminated through decontamination

Riot control agents → non-lethal (tear gas, sternutators, skin irritants)

- powders
- easily eliminated through decontamination

Managing bodies exposed to chemical, biological, radiological or nuclear agents [8, 5, 16]

The first step is to evacuate survivors/injured from the disaster site. Human remain management will then require that bodies be handled and moved.

- Recovery of bodies
- Body collection site
- Forensic examination (causes/circumstances of death, identification, collection of evidence/samples from bodies)

These procedures will expose responders to hazardous agents, which may be disseminated into the population and environment when the bodies are moved.

Where possible, and in an effort to minimize global risk, it is preferable that deceased bodies be decontaminated before they are handled/moved.

Decontamination is effective in the following situations:

- external contamination of a dead body by an agent, for example death due to injuries (explosion, accident) with exposure to a CBRN agent
- example: dirty bomb, fire shell, explosion in a P4 laboratory
- death due to irradiation and contamination (RN)
- death due to exposure to a persistent chemical agent

Decontamination is of little use in the case of death following infection with a B agent.

This could occur, for instance, in the days following the dissemination of a B agent, upon the discovery of dead bodies infected with the agent in question. It would be impossible to rid the organism of the B agent, and therefore dangerous to handle the body.

Decontamination would be ineffective, regardless of the mode of contamination, in the case of injured and fragmented bodies, as contaminants could be deeply embedded in the wounds.

But decontamination is still recommended, since in all instances it reduces overall risk. There are three options for the management of deceased bodies that have been exposed to a CBRN agent.

### *Interment or cremation – Bodies not handled*

Public health authorities may opt for interment/cremation in the wake of a very large-scale disaster, when there are simply too many dead bodies to manage (e.g. nuclear explosion or uncontrollable dissemination of a severe epidemic like smallpox among the population).

In such instances, victim identification must take a back seat to protecting the health of the public.

### *Identification of bodies without prior decontamination*

In this scenario, bodies are handled and forensic operations are carried out with no prior decontamination.

This procedure requires that bodies be moved only as far as is necessary from the disaster site to minimize the risk of further dissemination of the agent.

In theory, this means processing bodies in the immediate vicinity of the disaster site and setting up an autopsy line, which in some cases may be located close to an urban centre.

This option poses major risks to responders. This procedure is addressed in the exercise described in Chapter 5.

### *Decontamination of bodies prior to forensic operations*

This option can significantly reduce risks for responders, as well as the public and environment.

How exactly things are done will depend on the scope of the disaster and, more importantly, the nature/dangerousness of the agent. Consideration must also be given to the risk-benefit balance for the general population.

## Recovery of bodies

Dead body management begins after survivors and the injured have been evacuated. There is no rush, and it is even recommended that responders take their time (a few hours) in order to properly identify the CBRN agent(s) involved.

Determining the agent involved can sometimes be a long and difficult task. RN agents are easy to detect, but C agents require a series of different tests. And it can take several days to pinpoint B agents, as there are no rapid identification tests.

Authorities must also consider the possibility that agents from different categories were released in combination.

Initial body management must be done in a methodical and formal fashion, based on the assumption that one or several of the most dangerous agents are involved.

The only sure determination first responders can make is whether or not radioactive material is present at the disaster site. The presence of C agents can quickly be detected using tests at the disposal of responders.



First responders will divide the disaster area into three zones: the exclusion zone, the controlled zone, where body collection/decontamination operations are conducted (body collection site) and the support zone, considered as risk-free. [10]

### Exclusion zone (disaster site) [1]

#### Respiratory protection (Fig. 1)

- self-contained breathing apparatus, SCBA (personal breathing apparatus with filtered, compressed air)
- filter mask with multi-purpose cartridge

#### Gear [9]

- decontaminable gear such as lightweight decontamination suit, with or without shoulder reinforcements for SCBA, with glove inserts, butyl gloves, butyl boots or over boots
- non-decontaminable filtering suit (T3P, S3P or TOM)

Both of these suits offer the same level of protection, but the advantage of filtering suits is they can be worn for long periods of time in extreme temperatures.

#### Specific material (if necessary)

- Geiger counter or similar device to detect beta particles/gamma rays, use of dosimetry if there is a radiological risk
- C agent detectors

In the event of radioactivity, the following is required:

- initial distribution map for radiation doses in given locations
- operational dosimeters for all personnel working in the exclusion zone, body collection site and decontamination zone
- system to record cumulative doses
- training to ensure minimal knowledge of radiation protection (dangers associated with doses)
- checkpoint personnel to control access to zones, keep records of individuals who enter zones, ensure dosimeter use and provide/reiterate security instructions

Depending on the radionuclide in question, there may be a delay before dead body management operations can get underway. For instance, radionuclides produced by a nuclear explosion are short-lived so responders can wait out the radiation period, but radionuclides used in a dirty bomb have a much longer life (a few years), in which case there would be no point in waiting to begin body management.

#### Figure 1 – The different zones [1]

If wind < 1 m/s      If wind > 1 m/s  
CONTROLLED ZONE  
BODY COLLECTION SITE  
SUPPORT ZONE      DOWNWIND DANGER ZONE  
EXCLUSION ZONE      IMMEDIATE DANGER ZONE

The recovery of bodies can involve the following procedures:

- videotape/record the scene
- photograph the bodies and nearby evidence
- map out the scene and record the position of evidence (GPS)
- number/label the bodies and nearby evidence using waterproof, chemical-resistant materials
- collect/label scattered elements likely to be of interest in the investigation
- collect/store non-human evidence in chemical-resistant containers that are impervious to volatile products

- place bodies in body bags, which are to be left open
- ventilate the area

Move the bodies from the exclusion zone to the body collection site.

In the exclusion zone, information must be collected in a paperless fashion, with no inter-human contact between responders from the different zones.

In practice, a laptop and digital camera are to be kept in the exclusion zone to record all relevant data.

Said data are then passed on from the exclusion zone using a USB key or, ideally, via a wireless connection.

### Body collection site

The body collection site is located between the exclusion zone and the controlled zone.

Exclusion zone gear must be worn at the body collection site.

This is where bodies/human remains are temporarily stored prior to decontamination.

Body collection sites must meet the following criteria:

- upwind from the exclusion zone
- out of public view
- refrigerated, if possible, especially if decontamination is not immediate
- covered and protected against animals/insects

Bodies are left out in the open, body bags are left open, and the area is well ventilated.

### Decontamination of bodies

The purpose of decontamination is to eliminate, neutralize or break down harmful agents (Fig. 2). For B and C agents, it involves washing and impregnating bodies with sodium hypochlorite, which destroys B agents and facilitates the breakdown of C agents. The concentration of active chlorine should be between 1% and 2% to optimize decontamination, while limiting toxicity for responders.

Radiological agents cannot be destroyed, only moved; sodium hypochlorite is not necessary for this risk.

*Figure 2 – Organization of body management operations*

#### Exclusion zone

BODY COLLECTION SITE  
Undress  
Rinse

#### Controlled zone

Wash – Soap  
Rinse  
Sodium hydrochlorite  
Rinse  
Bag  
Storage

#### Support zone

Morgue  
Personal effects

Decontamination operations are organized in assembly line format.

Bodies should make their way through the decontamination line with minimal manual handling and as quickly as possible. The system must allow for the exposure of all body parts.

A gurney with large mesh could be set up on a rail system to rinse and saturate bodies with sodium hypochlorite, eliminating the need to handle bodies.

Responders at the start of the decontamination line must wear the same protective gear as required in the exclusion zone. Those located at the end of the decontamination line are not required to be as fully protected.

The decontamination line is set up in the controlled zone, also upwind from the exclusion zone.

Ideal conditions include:

- availability of running water
- protection of ground against leakage
- slanted surface to facilitate runoff and cleaning
- drainage and wastewater recovery system
- electricity

### Organization of decontamination line

Stations can be set up along the decontamination line for the following tasks: [6]

- receive body and check number assigned to body
- photograph the clothed body/details of clothing
- remove all clothing from the body, paying close attention to the undressing phase & clothing carry most of the body's external contamination & the safest and easiest method is to cut the clothes off the body and leave them in the body bag
- place the body bag/clothing in a leak-proof, numbered container
- photograph identification papers/telephones/jewellery not firmly affixed to the body and place them in leak-proof, numbered containers
- leave jewellery firmly affixed to the body (earrings, piercings) intact
- decontaminate the body/human remains
  - > absorb toxic liquid/solid (C risk)
  - > cut hair if there is obvious contamination (C risk essentially)
  - > rinse the body
  - > wash with soap and water, focusing on the head (mouth, ears, eyes, hair), using a soft brush or sponge
  - > rinse
  - > spray thoroughly with a 1%-2% sodium hypochlorite solution and let it act for five minutes (minimum) to 15 minutes (ideal)
  - > rinse

Spraying alone does not guarantee proper decontamination, especially if elements are soiled with greasy, organic or proteinic materials, such as blood clots. Mechanical cleaning (in which the body is scrubbed with a soapy solution) is imperative before the sodium hypochlorite solution can be sprayed on the body.

Alternatively, the body can be immersed in a sodium hydrochlorite bath. A special container is required, enabling responders to:

- handle the body (lift/lower body into bath)
- renew the decontaminating solution and control the concentration thereof

At the end of the decontamination line, responders can wear less protective gear and must complete the two following tasks.

- > Place the body in two leak-proof body bags (double bagged) and disinfect the outside of the bag. Special CBRN body bags are available on the market, for instance those manufactured by UK-based company Remploy Frontline.
- > Store the bodies in a refrigerated container.

## Management of personal effects

Personal effects (clothing, identification documents, jewellery, watches, telephones, etc.) are removed from bodies at the start of the decontamination line (undressing phase).

Personal effects are placed in leak-proof containers, which undergo external decontamination prior to leaving the controlled zone.

Specialized firms process personal effects in a secure environment.

Only personal effects of value (e.g. jewellery) and forensically relevant elements are decontaminated.

Depending on the risk, most personal effects will have to be destroyed.

## Forensic examination – Morgue

At this point, the agent in question has been clearly identified. The risk is therefore known, and bodies have been decontaminated as best they can.

### **RN risk**

The decontamination process eliminates the external contamination of a body by radioactive dust.

Residual radioactivity (internal) is known because it was detected upon leaving the decontamination line. It will be clearly indicated on the bag.

All that persists is radioactivity resulting from the ingestion/inhalation of radionuclides, a priori, in very small quantities, but mostly radioactivity resulting from the presence of radioactive residue in wounds (shrapnel).

Internal contamination resulting from the ingestion/inhalation of radioactive material should deliver low enough dose rates so as not to endanger responders working in proximity of the body. But radioactive shrapnel must be removed with forceps, where possible.

Responders must wear protective gear 5 or 6 with an FFP2 respirator mask. Shielding can be added, if necessary.

When a dose rate persists, external and dental examinations must be done quickly. Internal examination is to be avoided. The collection of samples for DNA analysis must be controlled.

### **B risk**

The biggest risk is accidental blood exposure (ABE). The use of sharp/pointy items is to be kept to a minimum.

Responders must wear protective gear 5 or 6 with an FFP2 respirator mask.

Internal examination is to be avoided given the risk of injury to responders. When anthrax is involved, cutting open the body will foster sporulation and the dissemination of spores.

The mandible should not be removed during the dental exam (risk of injury).

Muscle samples for DNA analysis must be collected quickly and safely with a special trocar instrument. The collection of bone samples is to be avoided, as the risk of injury is high.

DNA analysis must be conducted in a P3 lab; P4 labs are not able to perform such large scale analyses.

## C risk

The AP2C chemical contamination control device can detect low concentrations in air of sulfur compounds like mustard gas.

Rigorous control at the start of the autopsy line, and when handling bodies with deep wounds, should make it possible to detect potential vapours.

The room must be fully ventilated and kept at a cool temperature to limit the vaporization of toxins.

Responders must wear protective gear 5 with an FFP2 respirator mask. A standard protective device (ANP filtering gas mask) or self-contained breathing apparatus (SCBA, personal breathing apparatus with filtered, compressed air) must be worn when there is a risk of persistent vapours.

The use of butyl gloves is recommended.

The duration of examinations must be kept to a minimum.

In the case CBRN contamination, even the most thorough decontamination is not enough to completely eliminate the risk. With respect to the handling of bodies and victim identification, every effort must be made to minimize the exposure of responders and the risk of injury. This is done by simplifying identification procedures. For example, with respect to dental examinations, removal of the maxilla and use of a probe could be replaced by a series of retro-alveolar radiographs and occlusal/lateral photographs. The odontogram can then be filled out at a later date in a safe environment.

Conventional reexamination procedures, whether to double check a finding or look for additional elements, must be kept to a minimum.

## Funeral arrangements

In general, every effort must be made to minimize risks regarding the transfer of residual contamination.

Upon the completion of identification procedures, bodies will remain double bagged in the refrigerated storage zone.

Corpses will not be cleaned or preserved.

Families will be unable to view the bodies of their loved ones.

### **RN risk**

Experts advise against incineration given the risk of dissemination of radioactive particles into the air.

The body will be placed in an airtight coffin, which will be marked with a trefoil to warn of potential radioactivity.

In the unlikely event that a body remains highly contaminated, burial in the controlled zone will have to be considered, following the same procedure as used for waste management in the nuclear industry.

### **B risk**

When dealing with contagious B agents or agents that are highly persistent in the environment (anthrax) and pose a threat to health security, incineration is the recommended course of action.

When incineration is not an option, bodies will be buried in airtight caskets equipped with a gas purification system.

### **C risk**

Experts disagree on how to proceed with C agents. Cremation destroys residual C agents, but poses an air-pollution risk. Incinerators equipped with special filters must be used.

Burial in airtight coffins is also an option.

## **Organization of disaster victim identification in France [6, 14]**

### **Conventional disaster**

In France, the Gendarmerie nationale and Police nationale each have a disaster victim identification unit. In practice, these two units pool their human/physical resources to ensure the best possible management of victim identification operations.

If a disaster occurs within the national territory, these units share body recovery and AM data collection duties. They may provide assistance to the forensic institute responsible for examining the bodies. If a disaster occurs outside the national territory and if local forensic resources are insufficient, medical examiners from the Gendarmerie nationale Disaster Victim Identification Unit are available to examine bodies.

The Police nationale Disaster Victim Identification Unit (UPIVC) belongs to the Central Forensic Identification Service (SCIJ). Members of this unit are skilled in crime scene management and disaster victim identification. This unit can work within the general organization of identification operations, in support to the AM team and has fingerprint/photograph specialists.

The Gendarmerie nationale Disaster Victim Identification Unit (UGIVC) is part of the Gendarmerie nationale Criminal Research Institute (IRCGN). This unit is able to manage the overall identification process. In fact, it is the only entity with a forensic component to work in partnership with the health service of armies (regular and reserve medical examiners/dental surgeons).

The UGIVC is deployable on a 24/7 basis and uses special equipment that is immediately transportable. For dental exams, the UGIVC has portable x-ray machines and a digital sensor system (no film) so photos can be archived directly onto a computer.

Together, the UPIVC and UGIVC form the National Disaster Victim Identification Unit (UNIVC). The UNIVC applies identification guidelines recommended by Interpol. This international law

enforcement agency has in fact proposed very specific methodology for disaster victim identification, providing a recognized basis for cooperation by international teams.

PM identification teams have to be created, trained and deployable immediately. Identification procedures get underway as soon as the disaster zone has been secured and the injured have been evacuated. A numbered reference grid is prepared for the zone; all recovered evidence is placed in bags, which are numbered in accordance with the grid.

Bodies and physical items (jewellery, personal effects) are numbered.

In the autopsy room, bodies are photographed, x-rayed and autopsied. Identification procedures via fingerprints, dental exams and DNA are carried out. All information is placed in the numbered PM file corresponding to the body being examined.

The organization/methodology of PM victim identification management procedures are clearly defined, but AM management of a disaster is much more complicated. In the absence of AM data, it is impossible to identify bodies. The collection of AM data is clearly a vital task, performed by staff trained to meet with families and contact practitioners. Physicians and dental surgeons are therefore required for this work.

Recent disasters (tsunami, Concorde crash) and the likelihood of terrorist attacks in large western cities highlight the international origin of victims. The AM team must be able to collect and translate data obtained in the homelands of victims.

AM data include photographs, verbal descriptions, medical/dental records, fingerprints and familial DNA.

AM data are analyzed and input on Interpol AM forms.

AM and PM data are compared in an effort to identify victims. Said comparison can be done manually for a small number of victims, or using an automated data comparison system in the event of mass fatalities (e.g. PlassData DVI software).

Following the comparison of AM and PM data, positive identification is announced by a commission composed of those in charge of the AM and PM teams.

### *Chemical, biological, radiological or nuclear disaster [15]*

In a CBRN environment, a team like the UNIVC requires support and assistance to ensure its security by teams specialized in CBRN risk management.

In the wake of the 1995 sarin gas attack on the Tokyo subway [13], the Gendarmerie nationale developed a CBRN action plan to ensure the continuity of its missions in the event of any such attack.

### National CBRN unit (C2NRBC)

France's only specialised CBRN unit, the C2NRBC of the Gendarmerie nationale, is tasked with helping Gendarmerie teams carry out their missions in contaminated areas.

Its 17 members are first and foremost CBRN experts.

Taking into account the entire range of the CBRN threat, the C2NRBC performs several duties:

- it provides technical/operational advice to the Gendarmerie operations commander in a zone where a CBRN risk/threat action plan has been implemented;
- it guides all investigators required to work in a contaminated environment;
- it trains Gendarmerie personnel;
- it shares its expertise with the Gendarmerie response team;
- in cooperation with other civilian and military agencies specializing in CBRN crises, it participates in meetings, discussions and national/international exercises; and
- it uses a special vehicle (Biotox-Piratox) to enter areas contaminated by biological and/or chemical agents in order to collect samples, analyze them in situ and transport them to a registered lab while ensuring the preservation thereof and compliance with judicial procedures.

The national CBRN unit is stationed at the Gendarmerie's armoured mobile division in Satory (Yvelines). It is deployable within three hours, sometimes in as little as one hour depending on the situation, by road or by air, in full autonomy or in conjunction with the CBRN operational subdivision, both in and outside France.

### CBRN operational subdivision (SGO-NRBC)

The SGO-NRBC is made up of four CBRN squadrons, one of which is on a permanent state of alert and deployable within three hours (one hour if necessary). Equipped and trained, constituting a rapid intervention unit and coordinated by a tactical headquarters, it can intervene in a contaminated area anywhere on national territory and is systematically accompanied by a C2NRBC unit. Its mission is to:

- secure a contaminated area by reinforcing public safety following a CBRN attack;
- evacuate/channel the population and escort convoys;
- maintain/restore public order;
- contain violence in the contaminated area;
- protect major government bodies in the contaminated area; and
- support operations carried out in a dangerous technological context involving the response team (GIGN), the Gendarmerie nationale Criminal Research Institute (IRCGN) or any other specialized judicial police unit.

### Gendarmerie nationale response team (GIGN)

The GIGN is part of the specialized teams that provide support to territorial units in the fight against CBRN threats, more specifically counterterrorism, the protection of VIPs and intelligence gathering.

GIGN members are fully equipped with state-of-the-art gear so they are able to operate in a contaminated area in complete autonomy.

### Territorial resources

In each defence district, two mobile Gendarmerie squadrons are equipped and trained to intervene in the event of a CBRN risk or threat.

All units in charge of an industrial site posing specific risks (Seveso sites, nuclear power generation station), as well as all Gendarmerie research units (search teams, search sections) and the IRCGN, are able to intervene in the event of contamination.

### Reinforcements

Based on the scope of the disaster, reinforcements could be sent in to provide assistance. Soldiers and firefighters/law enforcement officers have at their disposal CBRB experts and equipment.



These responders and their equipment are dedicated to rescue operations. The adaptation thereof to dead body management, the definition of individual roles/responsibilities, the availability of personnel and the loan of material are all key organizational items which have to be clearly defined.

## Identification exercise in a contaminated area without prior decontamination

### *Context / Organization*

As part of a joint IRCGN/C2NRBC study on potential techniques for use in a CBRN environment, an exercise was organized in November 2009 in the Paris area to determine if IRCGN forensic teams, in association with C2NRBC specialists, could autopsy non-decontaminated bodies in a tented forensic facility, similar to what was used following the tsunami or earthquake in Haiti.

Focusing on animal research, IRCGN specialists obtained the carcass of a farm pig, not yet gutted and placed under the permanent control of veterinary services. Thirty IRCGN and C2NRBC soldiers set up the forensic examination line and the full C2NRBC system. The forensic examination line included an x-ray station, an autopsy station and, lastly, a dental exam station. All three stations were set up in special tents with plastic flooring to protect against the leakage of fluids. The tents were installed in a closed building, where the floors had also been covered with tarps.

Each forensic examination station was inspected to ensure management of potential leaks.

The C2NRBC system included a command post, a personnel suit-up area and a decontamination area.

Three teams worked their way through the autopsy line over the course of the day in order to assess as accurately as possible the limitations of the exercise.

Presence in the zone was the responsibility of the C2NRBC. All two-person teams entering the zone were accompanied by a pair of C2NRBC officers. This requires a lot of physical resources, but ensures a high level of security. The active two-person team was supported by hands-on personnel, available to provide material assistance, with other responders in full action.

A beaten path was set up to optimize the movement of staff, helping to save time and increase the effectiveness of responders.

### *Exercise process [3]*

The first team was in charge of taking x-rays, i.e. full body and dental (Fig. 3), using a system of plates which were later developed. This series of plates were protected against contamination, and decontaminated upon leaving the zone to avoid any possible proliferation of contaminants on the body. The C2NRBC controlled all access to the zone.

Operations could be watched live via a head cam, which not only ensured the security of responders at work in the zone, but also made it possible to see how things were progressing and anticipate the steps to be taken next.

The second team then performed the autopsy on the pig.

And lastly, the third team performed the dental exam, in this case first removing the maxillae. Practitioners were easily able to perform the extraction, unhindered by their protective gear.

The thick gloves worn by medical examiners as part of their CBRN gear did not hinder their ability to perform the autopsy, but simply made it a little more difficult to move their hands as freely as they would in normal autopsy conditions. Their protective gear did not hinder the movement/adjustment of equipment used to increase visibility, such as lighting.

When selecting a location for the exam, care must be taken to ensure there is plenty of room to move around the autopsy table.

C2NRBC personnel must be present at all times to oversee operations, ensure the security of responders and provide immediate assistance, as required.

### *Figure 3 Identification exercise in a CBRN environment*

#### Lessons learned

There has to be as much synergy as possible between the C2NRBC and IRCGN, requiring highly efficient organization of resources at the site. A representative from each of these units must decide on how to proceed as soon as the site layout, examinations to be conducted and residual risks are known. Both units have to be deployed as soon as possible and simultaneously.

Flexibility is limited and routine crime-scene operations are considerably more complex in CBRN interventions, based on the nature of the risk, the definition of the different risk zones and the evolutionary nature thereof depending on environmental conditions, more specifically aerological conditions, as well as security guidelines to be applied and protective gear to be worn. As such, tasks take much longer to complete, i.e. preliminary operations, on-site interventions and removal of personnel/samples. More frequent staff rotations are necessary in order to relieve responders working a CBRN environment, who face tremendous stress and find themselves limited by bulky protective gear. It is therefore a very slow process – staff rotations have to be carefully planned based on the time it takes for relief teams to suit up and the time it takes for teams exiting the zone to be decontaminated. Both units must work out of the same command post to ensure flawless coordination.

Because teams have to be rotated so frequently, the operation requires a very large pool of employees to keep examinations as short as possible.

An operation of this magnitude can be entrusted only to agencies with the necessary expertise/resources in the forensic investigation process (search/identification of potential terrorist(s), identification of authorities, bodies with severe wounds and which cannot be decontaminated, collection of samples from bodies, etc.).

When attempting to identify CBRN victims without prior decontamination, no more than two autopsies per day per team seemed feasible.

It must be noted that this exercise did not factor in management of the most highly contaminated element: clothing. In a real-life situation, removal of clothing from bodies will cause aerosolisation of the CBRN agents, thus contaminating the air in the autopsy room.

Decontamination is therefore vital prior to the autopsy stage. Undressing and decontaminating bodies before they reach the autopsy line will help minimize the risk to responders, who will then be able to wear less protective gear and thus more easily perform their duties.

#### Looking forward [12, 4, 7]

As set forth above, managing bodies contaminated with one or several CBRN agents is a difficult task. We have to find simpler and/or safer ways of identifying victims as quickly as possible, with minimal exposure of responders to said agents. The focus is on finding ways for responders to perform exams while bodies remain in leak-proof body bags, without ever having to handle the corpses.

One option is to use fully transparent body bags, allowing responders to make visual observations (physical features of body, clothing, etc.) without having to open the body bags, thus limiting the

risk of dispersion of contaminants. The systematic use of a full-body x-ray system (through the body bag) would make it possible to obtain vital identification data (anatomical/dental), as well as information on the nature of possible injuries. In the absence of sufficient information for a positive identification, DNA would be collected.

Another promising option is the use of state-of-the-art medical imaging techniques, more specifically 3D reconstruction software.

With digital x-ray technology (computed tomography), magnetic resonance imaging (MRI) and photogrammetry (3D optical scanning), the forensic examination of a body could be done by looking at images and taking samples from the body (toxicology, DNA).

Virtopsy, a research project developed by the Institute of Forensic Medicine of the University of Bern, in Switzerland, is a highly advanced virtual alternative to traditional autopsies. The goal is to revolutionize current procedures by replacing them with analysis of internal/external 3D images of the body.

On an experimental basis, after a body goes through the imaging system, forensic pathologists are able to determine cause of death, perform the autopsy, estimate the victim's age and detect identifying features.

For example, a CAT scan of a skull using 3D software can produce an image very similar to a panoramic x-ray, for easy comparison with AM x-rays.

These new technologies will not replace, in the short term at least, traditional autopsies, but they are especially promising in the field of forensics and would clearly be of great use in the management of contaminated bodies following a CBRN incident.

At the scene of a CBRN disaster, responders would take photographs, fingerprints and blood/muscle samples for DNA analysis. Jewellery and items of value would be removed, and the body would be permanently double bagged in leak-proof body bags. The external, internal and dental exam would be conducted using imaging technology, with no direct contact with the corpse.

Although not as reliable as a direct visual examination by the forensic pathologist, especially for the external or dental exam, this solution would allow for an initial triage and significantly accelerate the identification of victims in the wake of a major disaster.

Traditional autopsies could then be performed on a limited number of bodies.

There are limitations to this technique, namely availability, the cost of imaging facilities and the training of image analysis operators. A recent article in the Journal of Forensic Sciences [11] describes guidelines in this regard.

## Conclusion

In the wake of a disaster, following the evacuation of survivors/injured, the manner in which deceased victims are managed has a big impact on public opinion.

Just as we have national CBRN plans aimed at preserving human life, we have to develop written guidelines detailing possible dead body management procedures.

The risk-benefit balance between conducting victim identification operations and ensuring the security of the population/environment has to be carefully weighed.

Whereas there is no hesitation about taking even major risks in an attempt to save a human life, it is an altogether different story when managing dead bodies. In the wake of a disaster, responders must never take further undue risks in conducting identification operations, and all resources at the disposal of authorities must be taken to minimize said risks.

In this context, body decontamination can often significantly help reduce the risk to both responders and the population. Decontamination can also have a very positive psychological impact in reassuring the public and quelling its irrational fear regarding CBRN agents.

In practice, decontamination would be done using previously deployed resources for the decontamination of surviving victims and therefore not require additional logistical capabilities. On the other hand, the autopsy room will require very specific organization and logistical support.

Dead body management in the wake of CBRN disasters is a very difficult task. Objectives and requirements have to be carefully thought out.

The development of virtual autopsy techniques could, in what we hope is the very near future, contribute to optimizing victim identification procedures and minimizing risks to responders.