MEDICAL MANAGEMENT OF CHEMICAL DISASTERS

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1. Introduction

In the absence of a comprehensive reporting system no accurate estimates on the number of chemical incidents are available.

Joined reports from three different reporting systems indicate that in the United States of America in 1986 an average of 1.6 hazardous materials incidents a day result in either death, injury, or evacuation (1). These data provide only minimum estimates of unintentional hazardous chemical incidents (1).

Chemical spills, releases, smaller scale accidents and near disasters are seen with sufficient frequency in the world to warrant serious attention to the potential for large-scale incidents.

A potential disaster can occur at every point in the cycle of production, storage, transportation, use and disposal of the chemical substances (2).

Chemicals that often feature in such incidents are natural gas, chlorine, gasoline, ammonia, sulfuric acid, hydrogen chloride, propane, phosgene, hydrogen sulphide and nitrous fumes (1,3,4). Organophosphorus and carbamate insecticides and chemical war agents are other potential sources for a large-scale incident (5). Hazardous materials accidents, including those chemical substances that are flammable, explosive, corrosive, reactive, or poisonous, will provide mainly thermal and chemical burns, inhalation injuries and systemic toxicity (2,4).

management of chemical disasters is often problematic because of the dramatic circumstances of such incidents, the lack of a coordinated planning and response, the problems about identification and the availability at the scene of the disaster of detailed toxicity data for most of the offending agents, frequent exposure to multiple toxins and the immediate and continuous risk for rescue and emergency medical system (EMS) personnel (2,5-9). Without some knowledge and preparation nd in the absence of close coordination and communication, what appears to be a minor accident can quickly become a major catastrophe affecting an entire community (4,7).

The community expects, in case of an hazardous materials disaster, that an effective relief will start. An efficient response of the emergency health care system must be rapid by a fast alert and a readiness of the various rescue services, must be adapted to the disaster and the medical assistance must be consistent and coordinated (10).

The aim of the emergency medical assistance in disaster situations is to provide as rapid as possible the greatest benefit for the largest number of casualties in order to achieve a critical reduction in mortality, morbidity and indirect effects within the affected population. The doctrine of the medical disaster plan is the medicalization of the rescue and relief operations (11). This is only possible if an optimal preparation (medical strategy or medical preparedness plan) is anticipated together with an effective execution (medical tactics and logistics and adjusted medical procedures or medical action plans) in order to return as soon as possible to a routine health care situation (10).

Medical strategy is the conception and elaboration of a medical preparedness plan according to a doctrine mainly the medicalization of the rescue and relief operations (11). The analysis of the various hazards must take into account all factors which can influence an effective response such as circumstances, location and environment of the disaster, the effects on population and the environmental disruptions, and also a potential evolutive risk. This analysis will lead to define tasks, functions and responsibilities but also a coordination system and a communication network and both the quantitative and qualitative needs. The frequency of the simulation exercises and the evaluation methodology must also be included in the preparedness plan.

Medical tactics consist of the mobilization, the distribution and the deployment of the resources in the field according to the nature of the intervention, the circumstances and the effects of the disaster and the nature of means in medical manpower, supplies and equipment. It requires also adjusted medical treatment procedures (10,12).

Medical logistics are the art of supplying which allow medical personnel to execute their tasks. They include various functions such as resupplying, conveying and distribution of drugs, medical supplies and equipment, relief of medical and paramedical personnel. This is only possible if the medical logistics are initially anticipated in the conception of the disaster plan (11). Medical tactics and logistics will constitute a medical action plan (11).

The medical disaster plan must be comprehensive in order to be executed in all mass casualty situations, but also, specific for particular disasters and dynamic in order to adjust the medical assistance continually according to the evolutive nature of the disaster and the collected informations.

An effective emergency medical assistance requires :

a. unity in doctrine as well in the planning of both predictable and non predictable disasters. A joint doctrine is necessary in order to allow a rapid integration of each rescuer in the chain of emergency medical assistance, each rescuer at his level of competence and in his speciality (10,11) ;
b. an unity in command, coordination and communication within the chain of emergency medical assistance (10,11) ;
c. an unity of action within the chain of emergency medical assistance necessitating an optimal integration in the general chain of assistance (11) ;
d. the mobilization of adapted and standardized means (10) ;
e. and a rapid intervention which is only possible of an optimal emergency medical system is functioning permanently (10).

The medical involvement is necessary as well in the planning as in the execution and coordination but also in the evaluation of the disaster plans. The medical action plan must be executed by competent personnel at all levels necessitating an education and training (10,11).

The normal and traditional health care structures such as the hospitals remain the key in the care of disaster casualties. But in order to meet the objectives of disaster management mainly the reduction of morbidity and mortality in the largest number of casualties, medical assistance and care must be started at the scene of the disaster.
Although in most mass casualty situations prehospital care usually will not be definitive treatment, it can not only alter outcome but also significantly decrease morbidity. Under special circumstances such as hazardous materials exposures care on the spot can be the definitive treatment.

The medical assistance and care in disasters will originate from the normal health care systems by a progressive reinforcement of the emergency medical system and by starting the hospital disaster plans.

2. Medical Preparedness Plan

The key to successful management of chemical disasters is preparation (2,3). A community wide medical preparedness plan is essential. Following elements are indispensable in the elaboration of a medical preparedness plan.

a. Epidemiology and data collection

History points out that collecting data on both minor and major hazardous materials accidents can only be obtained by promulgating and enforcing laws on incident reporting (1).
Data indexed by name of chemical, type of incident or spill, extent of exposure, parties involved and information about deaths, injuries and evacuation must be collected, compiled and stored in a centralized reporting agency (1,12).
Emergency departments must also contribute to the collection of epidemiological and medical information of hazardous materials incidents. Data collection includes a history of the chemical exposure, a complete patient interview, review of current symptoms and complaints, identification and toxicity of the offending agent(s) and the administered treatment protocols (13).
Lessons learned from chemical incidents can be consulted by all rescue services in order to plan preparedness and response based on experience.
Data collection will include among others :

(1) Hazard mapping with
   (a) identification of potentially hazardous fixed or mobile activities ;
   (b) risk analysis of installations or activities ;
   (c) identification of potential emergencies and their extent ;
   (d) dispersion model of a gas cloud and risk analysis for the rescuers, the victims and the population ;
   (e) determination of damage caused by the hazardous materials resulting in damage area, number of casualties and types of injuries (thermal and/or chemical burns, blast, inhalation injuries, systemic toxicity, blunt or penetrating trauma) ;
(2) data on the various chemicals, including information on generic name, trade name, identification number, physico-chemical properties, fire hazards, health hazards, recommendations for rescue personnel, need of protection and information on first aid and possible antidotes ;
(3) community profiles which contain not only information on the population itself but especially on facilities requiring special protection and/or consideration in chemical incidents ;
(4) data on available resources in the local community, and on regional or national resources as indicated.

b. Structure of the emergency medical assistance

Both general and medical command and coordination structures will clearly be delineated.
The various operational relief services who will intervene in the emergency medical assistance and care must be appointed with an enumeration of their tasks and the way of operational coordination.
The functional diagram of the chain of emergency medical assistance with the various actions and facilities in the different disaster zones will be described such as search, rescue and first aid in the intervention zone, the medical command post and forward medical post for triage and field care in the safety zone and a coordination committee, receiving medical facilities and reception centres in the rearward zone.

c. Tasks

The principal tasks of the medical assistance in disasters include the overall coordination of health care, preventive measures, the reconnaissance with evaluation of evolutive risks, number of casualties and the predominant injuries, the mobilization of medical personnel, supplies and equipment, the medicalization of the rescue with triage, stabilization, conditioning and evacuation of the casualties to care facilities, the psychological care and social aid, the establishment of a mortuary, the environmental health response, the medical care in reception centres, the testing and evaluation of the medical disaster plan.

d. Functions with job description

The various functions within the chain of medical assistance together with a job description must be detailed such as the alert centre, the director of the emergency medical assistance (medical officer in charge at the site), the mobile medical teams at the scene of the disaster, the physicians responsible for the forward medical post(s) and for dispatching the casualties, physicians without training in emergency medicine, etc.

e. Alarm

The preparedness plan will include the alarm procedures with the different alarm phases and the alarm threshold. The alarm threshold will mainly depend on the actual treatment and transport capacity of the emergency medical system and hospitals of the community or region but also on the number of casualties and the seriousness of the injuries (14).
The different individuals who can start and the way to start the medical action plan must also be inserted in the preparedness plan.

f. The intervention phases

According to the extent and the nature of the incident and to the expected effects or the necessary resources, the medical assistance can proceed in different phases which must not necessarily be passed through in a chronological order, such as internal, local, regional and national medical action plans.

g. Logistics

An inventory of existing resources in manpower and material and an assessment of the needs both on the quantitative as qualitative level is necessary.
In chemical disasters specialized teams in detection and identification of the toxic hazards at the scene of the accident is essential. Experts in the management of chemical disasters are also needed for giving advise to the persons in charge of the command and coordination of the disaster.
Chemical mass casualties require both specific medical supplies and equipment and non medical material in great quantities such as oxygen, antidotes and means of protection and decontamination.
It is necessary to identify executive functions and also specific functions such as physicians and nurses.
An inventory of the different means of transport and the local and regional transport capacity must be included in the preparedness plan.
It is clear that command, coordination and control within the chain of medical assistance are only possible if adequate means of communication are provided because the multiplicity and dispersal of emergency aid personnel and the distances between the different echelons (11).
An inventory of the hospitals of the region and their actual treatment capacity in disaster situation must be drawed up in the preparedness plan. In chemical disasters emphasis should be laid on specialized treatment capacities such as burn centres, intensive care units with number and type of respirators, hyperbaric oxygen centres, hospitals with decontamination facilities and stocks of antidotes, toxicological laboratories and poison centres, etc.

h. Communication network

At least three radio networks are needed in the chain of emergency medical assistance : a commando network for coordination with the other rescue forces and the authorities, a functional network for command, control and coordination within the chain of medical assistance and a regulation network for dispatching the casualties. A diagram of the tactical radio network of the emergency medical assistance must be included in the preparedness plan.

i. Testing and evaluation of the medical disaster plan.

Regular exercises must be planned in order to test the operationallity of the medical disaster plan. The frequency of the exercises must be indicated in the preparedness plan.
An evaluation methodology must also be included. Besides epidemiological data evaluation generally focus upon structure, process and outcome of the medical disaster plan as well as adequacy and cost of the medical disaster response (15).

3. Medical Action Plan

In many countries hazardous industrial sites and hazardous materials transport come under the control of specific regulations which include a requirement for emergency planning to be undertaken on site and in the surrounding community. The medical disaster plan is a part of the overall emergency planning.

General principles of the medical action plan in hazardous materials incidents include preventive measures, alert, mobilization of health means, reconnaissance with localization and identification of the toxic chemical agent(s) and of their inherent risks on site and to the community, the deployment of the means of medical assistance, the medical field management including protection, containment, decontamination and neutralization of hazardous materials,protection or evacuation of surrounding population, medical care on the scene with triage, resuscitation, stabilization and evacuation of the casualties and specialized treatment in the hospitals.

Generally the fire services and civil protection agencies are responsible at the scene for containing the hazard, making it safe and managing the non medical logistics, police secure the area and emergency medical system personnel provide care for the casualties.
Local hospitals should incorporate management of hazardous materials incidents into their internal and external disaster plans (2,3,5). Development of a periodically rehearsed hazardous materials response system is the best preparation for such accidents (2,5).

a. Preventive measures

The likelihood of chemical disasters will increase with the aging chemical plants and safety precautions are often early victims of corporate cost-cutting and desinvestment decisions (12).
Protection of the public health requires stringent regulations to ensure new incentives for safety, a safe siting of the plant, improved surveillance and inspection (1,12).

Collaboration and coordination are essential in elaborating preventive measures. National authorities in evaluating and harmonizing regulation guide-lines, codes of practice for the production, storage, handling and safe transport, of hazardous chemicals should involve all sectors including health (12,16,17).

Agencies and professional groups concerned in planning for and responding in chemical disasters need to develop much closer links and the sources of expertise available in an hazardous materials incident should be identified locally, regionally and nationally (3).

Access to information for the population and the different rescue services is essential on the preparedness of the community and must be regulated by appropriate "right-to-known" laws (12). Information management on different levels is of vital importance. The community must be educated and informed through messages they can understand. Involvement of the media at all stages is important (16).

The potential risks of hazardous materials at production, storage and utilization sites in the community must be analyzed (2).
Transportation routes and their loads of hazardous materials must be examined.

Accurate and complete data on deaths, injuries and evacuations resulting from acute hazardous materials releases at these sites linked with information about commodity flows and geographic distributions of chemicals would allow calculation of rates to identify industries, types of facilities, activities and areas of the community with higher risks of having releases with public health consequences (1).
Computer models of the dispersion of dense gases can be applied to estimate broadly the numbers of death and acute casualties for serious but reasonably foreseeable accidental releases (3).

Public health professionals must provide communities and employees in hazardous industries with the knowledge and skills needed to institute and maintain effective controls of industrial hazards (12).
Emergency department personnel should teach hospital employees about hazardous chemical and compile data sheets containing information necessary for recognizing the hazard of a particular material, the safe conditions for handling it, the emergency procedures for containing or neutralizing it, and the first aid measures needed for exposures (13).
Poison centres also play an important role in both the acute phase and the pre-impact phase by given information on risks, possible health effects and treatment in case of exposure to a toxic chemical (17).

During the last years decision support systems were elaborated in order to ensure effective emergency response in chemical disasters. These systems include registrations of accident information, material information, geographical and/or demographical information, effect and damage calculations, evaluation of different emergency response strategies, operational information and perform automatically emergency response actions (18).

b. Alert

The medical action plan will include an alert diagram and the alarm procedures in order to mobilize the different health services, to inform the authorities and to start the medical action plan.
The population must be informed at an early stage about a real or potential hazard and must be instructed on their protection in order to normalize the behaviour of the public and to facilitate confining and evacuation measures.
The responsible authority for giving this information and the different ways of spreading this information must clearly be defined in the medical action plan (17).

c. Mobilization of health means

The mobilization of the various medical care services is based on a progressive reinforcement of the local, regional and national health care systems especially the emergency medical system.
Specialized means such as mobile decontamination units and individual or collective protection means must be mobilized as soon as possible.

d. Reconnaissance

The recce is important in order to complete the information collected during the alarm particularly concerning the effects of the disaster : data on the incident itself including nature, extent, geographic location and presence of an evolutive risk, effects on the community including the number of casualties and the type of injuries, the accessibility of the casualties and situation of surrounding population, material effects and facilities and means still available for medical care in the field (11).
In hazardous materials disasters the reconnaissance will include detection and identification of the chemical(s) but also an evolutive risk evaluation for the rescuers, the victims and the population.
Identification of the toxic substance and procurement of data on its physical characteristics and toxicology are vital to preventing access to the area, health, safety and protection of on site personnel and casualties, and to evacuation of surrounding inhabitants (2,5,13).

Evolutive risk depends on the toxic load, physical properties, meteorological conditions and the possibilities of neutralization of the toxic (19). It will be assessed by successive detection measurements. Various detection systems are available such as manually operated gas detectors consisting of hand-operated bellow pumps equipped with test tubes with a reagent for the specific material to be detected and more advanced portable devices sometimes installed in a car.
Detection can be carried out in order to confirm the presence of a deleterious gas already identified at the time of an accident which has led to the release of a certain quantity of the product. Successive detections allow to trace the advance of the toxic cloud, to mark out the safety area and to anticipate the medical response. Detection can also be carried out in order to identify a specific toxic in a set of hazardous materials likely to have contaminated the atmosphere or to confirm the absence of a previously present toxic indicating the effectiveness of the neutralization (19).
Anyway this detection in the field requires specialized personnel, perfectly trained and protected. Industrial or public hazardous materials (HAZMAT) teams can be requested and dispatched to the scene (2,5,13). HAZMAT teams emphasize detection, safety, containment, decontamination and clean up rather than medical treatment (2). A medical HAZMAT team may need to be deployed to make an urgent clinical and epidemiological assessment of the health impact and ascertain the sources and extent of a toxic exposure in the population (3).

The chemical(s) involved need to be rapidly identified (3,13), but identification may be delayed because skills needed rapidly to evaluate on the hazard are not available locally or impossible in releases from uncontrolled chemical reactions or fires (3,5). Even if the identity of the agent is known, knowledge about its human toxicity may be spare, as was the case with methylisocyanate at Bhopal with subsequent mismanagement (3,20).
At a manufacturing or storage site, this information should be ready available on location (2).
At the site of a transportation incident the hazardous materials may be identified from the hazardous chemicals (HAZCHEM) codes displayed on the vehicle or from the shipping papers (3,4,5). The identification number on the HAZCHEM placard may be cross-referenced with a guidebook on hazardous materials for basic physical characteristics, rudimentary toxicologic data, the necessary emergency action and appropriate first aid for victims (2,4).

There are problems with identifying materials through placards alone. Sometimes the code is missing, incorrect, destroyed or not visible (4). Shipping papers should be available on the vehicle or with the driver. Trucks carry a bill of loading and trains a consist and way bill. The consist lists the order of the cars and the way bill their contents (2,4).
Unfortunately shipping papers and way bills can be lost, destroyed or burned up (4). Determining the order of railroad cars, even with the aid of a consist, can often be difficult too. In a major derailment, the cars can become so jumbled up that the original order may be impossible to ascertain (4).
Other resources include access to computerized databases for information on hazardous materials and to poison control centres for more complete medical data (2,3). Ultimately, the manufacturer will be identified and a medical or scientific representative will assist in eliciting pertinent information (13).

Communication between the different rescue services (fire brigade, police, EMS personnel) about the identification of the chemical substance and its toxicity is essential in the medical aspects of management of chemical incidents (7). Once the chemical has been positively identified, the pertinent information must be given to the proper individuals to expedite control of the hazard and to minimize casualties. The information is given to the officer in charge (OIC) and/or the medical OIC at the scene of the incident. It is their responsibility to make sure the information is relayed to the proper individuals at the scene and that necessary measures are carried out. Once they have being notified the emergency department staff physicians are informed for adequate preparation before receiving any victims (13).

Identification or information on a toxic chemical or a category of hazardous materials can also be obtained by the assessment of the symptoms and the seriousness of the injuries in the casualties. Although in most cases symptoms are immediate, in some cases symptoms may develop after a latent period of hours or days after the acute exposure (7,17). In many chemical incidents it is impossible to wait for the results of the toxicological investigations in order to implement the emergency medical response.
Close observation of the clinical signs or symptoms in the casualties will impose the necessary medical assistance and care (19). Information on the approximate time of exposure, distance from the spill, time of arrival and duration of symptoms is also essential for the medical management (7).
Beside the clinical status of the casualties, their dispersal in a given geographical area will allow information about the dispersion of the toxic (19).

Symptoms may be local, systemic or both (11,17).
Acute local symptoms include isolated or associated signs consequent on injuries of the skin (prickling, chemical burns), the eyes (smarting, lacrimation), the respiratory tract (tickling or burning throat, cough, increased secretions, dyspnea, chest burning or tightness, bronchospasm, stridor, cyanosis) and the gastrointestinal tract (nausea, vomiting, diarrhea).
Acute systemic symptoms include those from the central nervous system (excitation, agitation, aggressiveness, depression, drowsiness, stupor, coma, muscular weakness, incoordination, seizures), the respiratory system (hyperventilation, hypoventilation, apnea), the circulatory system (arrhythmias, hypotension, cardiodepression), and the gastrointestinal system (nausea, vomiting).
Any affected organ system can provide delayed symptoms but most commonly the respiratory tract (delayed pulmonary edema), the liver and the kidneys.
Local and systemic symptoms combined with the dispersal of the casualties can give some indications of the offending toxic agent(s).
After identification of the toxic, its spreading can be traced in function of time, microclimate and local geography leading to delimitation of the contaminated area. Casualties inside this area will not be exposed to the toxic agent to the same extent owing to these environmental factors, to possible sheltering and physical activities (3,21).

e. Deployment of the emergency medical system chain.

The disaster area will be subdivided into different zones which are determined by the human and material effects, the probability of an evolutive risk and the possibilities of establishment of temporary field facilities for medical care and command. The means in medical manpower, equipment and supplies will be determined and deployed according to the needs and the availability of these means.
In a chemical accident the disaster area will be subdivided into 3 action zones : the contaminated zone, the contaminative or threatened zone and the protected or shelter zone (figure 1).

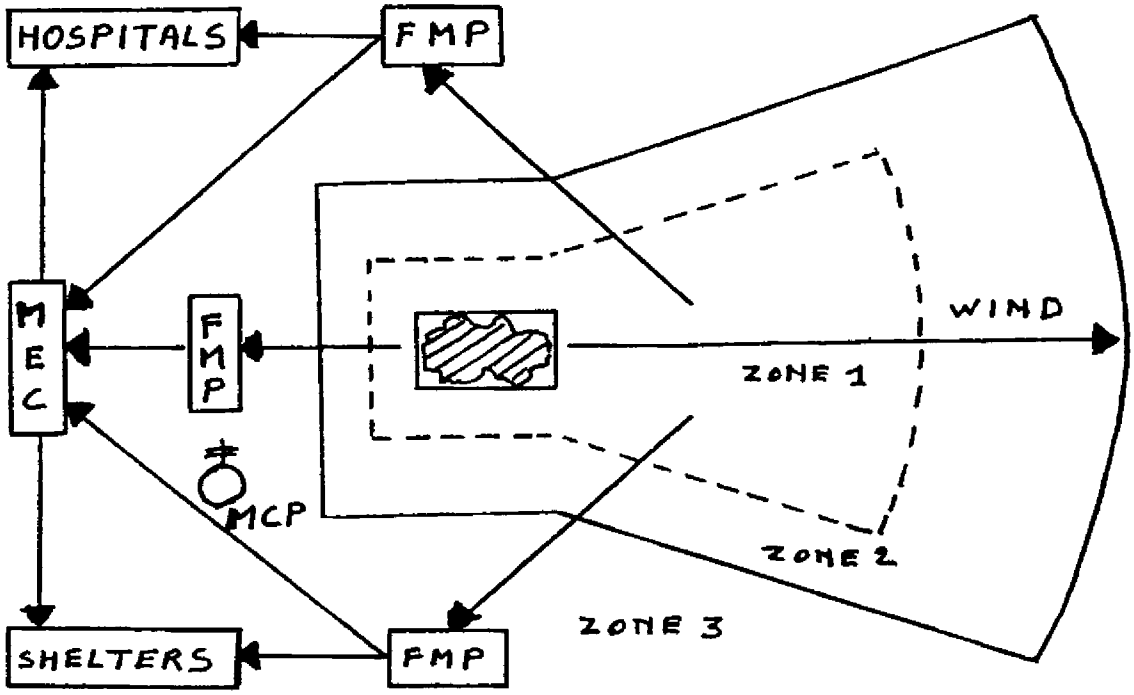

Figure 1. Subdivision of disaster area in different action zones. Zone 1 = contaminated zone, Zone 2 = contaminative or threatened zone, Zone 3 = protected or shelter zone, FMP = Forward Medical Post for triage and stabilization of casualties, MCP = Medical Command Post, MEC = Medical Evacuation Centre for regulation and transfer of casualties, only in mass casualty situations.

f. <u>The medical field management</u>

Hazardous materials accidents can include a wide spectrum of specific injuries, chemical burns, inhalation injuries (toxic gas or smoke), systemic toxicity but thermal burns, blast or other traumatic injuries and psychological disorders must also be identified (2,6,17,22).
At the incident site, medical field management should follow general rules for disasters, but also integrate the characteristics of hazardous materials accidents.

The medical assistance strategy in chemical disasters commands to know the extent of toxic release, the evolutive hazard in time and space, the technical possibilities of neutralization and/or destruction of the toxic chemical(s) and the clinical effects (19).
Whatever the nature of the toxic, the field management should meet specific requirements. It must be early and fast, which implies a systematic medicalization of the rescue ; it must be initiated by first aid workers (company, fire brigade, ambulance personnel) relieved as soon as possible by EMS personnel ; it requires attention to the safety of the rescuers and to prevention of further damage by removal of the toxic agent, protection, decontamination or evacuation ; it must take into account the short-term developments in order to determine the methods of evacuation and the hospitalization facilities for definitive treatment (6,17,19,22-24).
Dealing with these victims requires special education, training and experience. Generally EMS personnel is not used to practise in a toxic atmosphere and local or regional specialized medical teams could be on effective response to expertise in managing chemical disasters.

(1) Technical actions

The medical field management starts with technical actions to fight or neutralize the cause and/or consequences of the hazardous materials incident. These technical actions must sometimes be carried out before search and rescue of the victims or can be carried out simultaneously with the rescue operations. Removal from the toxic agent(s) to prevent further local damage or systemic toxicity is essential in the initial management of the casualties on the scene of the chemical disaster. Additional hazards from fire and explosion of combustible products must be assessed (23).

(2) Protection

The most important rule for medical responders to toxic releases is their own protection from chemicals and contaminated casualties, equipment and environment (2,4-6,17,22), the health-care providers become a liability rather than an asset if they are injured or contaminated while giving care (2).
Methods of self-protection of medical personnel are wearing adequate protective gear and insuring thorough decontamination of the casualties (5).
The decision to provide the medical personnel with some type of protection depends as well on the nature of the suspected toxic, the nature and the duration of the operations and the protection means immediately available in the equipment of the rescue personnel or the EMS personnel (19,22).

Some chemicals may require no more than ordinary garment most EMS personnel carry for management of day-to-day emergencies such as coats, gloves, boots, masks and goggles.
Impermeable sleeved aprons or suits providing total encapsulation and self-contained breathing apparatus may be needed in hazardous materials incidents that pose a higher than normal risk to the medical personnel (2,4,17,19).
Wearing special protection equipment may limit their capabilities in the treatment of casualties (2,19).
Medical care providers are usually not familiar with special protection equipment. If they do go into the toxic area, they should be adequately trained and should used this equipment routinely otherwise close cooperation with the fire brigade is essential in the rescue of casualties.

Protection methods must be considered in casualties who must be transported through a contaminated area in order to prevent worsening of the poisoning taking into account the speed of removing the casualties from the toxic environment and the persistence of the toxic chemical (19). The medical officer in charge has to choose from several methods. Although oxygen mask inhalation is an ideal method in sofar as it contributes already to the symptomatic treatment, it has in fact a number of drawbacks : difficulty in ensuring a total airthightness even in collaborating casualties, the need for a great number of personnel in order to maintain the mask and to supervise both equipment and patient handling and slowing down the rescue operations. The use of quick-entry air masks is limited by its inefficiency in some toxic environments. An effective but expensive method of individual casualty protection is the use of impermeable suits or bags supplied either by oxygen or by filtered air. This protection method can only be used in collective emergencies if the rescue services are equipped with many of these impermeable bags (19).

Protection of population is usually not a medical responsability. Confining or evacuation need to be considered for residents or individuals present in the dangerous zone or in a zone susceptible to be contaminated in short time (2,3,19).
Effective confining in public, domestic or company premises depends on good if not total airthightness of the premises, on the ability to determine the moment of reversion to normal conditions either by neutralization of the source or by action of the natural elements (wind, precipitations) in order to consider confining of short duration and on disposal of information procedures and communication means in order to avoid panic among the population that would like to run away without precautions (19).

A decision to evacuate the surrounding population depends on the nature of the toxic hazard, its explosive or flammable properties and prevailing weather conditions, local geography and population density (23). The decision to evacuate is often made hastely using unadequate information. In short releases without residual contamination evacuation can lead to more injuries and psychological trauma than if people stay indoors (3). Evacuation includes the problems of notifying the population, removing and sheltering them to a safe place.
Rescue or immediate evacuations will be carried out quickly due to the imminence of the toxic hazard. It concerns a more or less limited number of people and protection measures are necessary if the evacuation route passes through the contaminated area (19).
Regulated evacuations will be carried out according to a plan which takes into account the risk and the number of individuals to be evacuated. Routes running across non contaminated zones will be chosen. Rapid individual and collective evacuation means will be used. Information of the population, traffic police and census and assembling of the involved population is essential (19).
Hospitals and other custodial institutions should have their own evacuation plans and procedures for transporting people when they are notified that removal is necessary (4).

(3) Decontamination

Decontamination is a fastidious and time consuming procedure which should only be applied when it is justified (21).
Decontamination protects the victims from continuous exposure to the toxic materials, makes easier the treatment and the evacuation of the casualties and is a very important factor in the containment of the toxic hazard (2,21).
Liquid remaining on the skin or clothing may vaporize and contaminate EMS and transporting personnel, ambulances and emergency departments and larges areas of medical facilities might be unusable for hours if non-decontaminated casualties are brought into the hospital (3,5,6,17,23).
Decontamination can be carried out in two ways : neutralization of the toxic agent or removal of the chemical from the skin and clothes of the casualties.
Neutralization transforms the toxic agent in an harmless product. This decontamination method can be ineffective in disaster situation because the lack of a specific neutralizing agent for many chemicals, late identification of the toxic and logistic problems regarding the storage of great quantities of neutralizing agents and their transport to the disaster area (21).