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Hospital preparedness for chemical and biological incidents in Hong Kong

香港醫院應付生化事件的準備

The risk of mass exposure to toxic substances has increased steadily during the twentieth century due to the expansion of industry and the deliberate development and use of agents of chemical warfare. Although Hong Kong is considered a relatively safe place, hoax anthrax attacks have occurred since 17 October 2001. People who have been seriously injured by hazardous materials have a greater chance of recovery without complications when appropriate emergency treatments are provided. Recognition and identification of hazardous materials, assessment of the conditions, decontamination, and protection of staff and facilities are important elements in the formulation of a contingency plan. The objective of this article is to outline the efforts of the Hong Kong Hospital Authority in formulating a hospital response to incidents involving hazardous materials.

在20世紀，由於工業擴張和化學武器的不斷發展和使用，市民接觸有害物質的危險已大大增加。儘管香港被認為是一個較為安全的地方，好像炭疽菌的惡作劇自2001年10月17日起已有發生。如果能提供適當的緊急應變措施，縱使市民被有害物質傷害，他們會有較大機會痊癒和避免出現併發症。懂得辨別和鑑定危險物品、評估環境、淨化有害物質及保護醫護人員和設施，是制定臨時應變措施必不可少的。本文主要簡述香港醫院管理局在制定醫院應付涉及危險物品事故的緊急應變措施。

Key words:
Chemical warfare agents;
Decontamination;
Hazardous substances;
Protective clothing

關鍵詞：
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Introduction

Hazardous materials (hazmat) incident is defined as an accident that involves contamination of person(s) by toxic chemical, biological, or radiological agents. The risk of mass exposure to toxic substances has increased steadily during the twentieth century due to the expansion of industry and the deliberate development and use of chemical warfare agents (CWAs).[1] The world's worst chemical industrial disaster, which occurred in Bhopal, India, on 3 December 1984, resulted in 150 000 casualties and 2500 deaths.[2,3] The horrifying memory of the terrorist attack on the World Trade Center in New York City on 11 September 2001 still persists.[4] In the modern world, terrorists will not only use conventional weapons, but also chemical, biological, and even nuclear agents. According to the Secretary for Security, Hong Kong is a relatively safe place. Hoax anthrax attacks have, however, still occurred since 17 October 2001. Hospitals with accident and emergency departments should be prepared to handle these incidents. Indeed, the sarin nerve gas attack in a Tokyo subway in 1995 has demonstrated that many casualties would arrive at hospitals using their own transport, thus bypassing the emergency medical service (EMS).[5] The objective of this article is to outline the efforts of the Hong Kong Hospital Authority in formulating a hospital response to hazmat incidents.

Hospital preparedness

Hospitals must acknowledge their roles as a component of the community-wide response system. People who have been seriously injured by hazmat have a greater chance of recovery without complications when appropriate emergency treatments are provided. The spectrum of hazmat incidents may range from a single affected person to mass casualty level. Hazmat incidents can also range

from a small release at a factory to rapidly expanding events that endanger a community. According to a survey done in 58 acute care hospitals in a metropolitan region in Philadelphia in the US in 1997, only 50% of the five counties had a hospital-wide disaster plan for a hazmat incident.[6] In Hong Kong, hospital preparedness for a hazmat incident started in November 1999. The main objective for preparation at that time was to cope with the increasing industrial hazmat incidents in Hong Kong.

Recognition of hazardous material—the six primary clues

Emergency personnel should always be on the alert that they may be treating a hazmat-contaminated patient. The US Department of Human Services, Public Health Service, Agency for Toxic Substance and Disease Registry[7] identifies six primary clues that may signify the presence of a hazmat. Hospital emergency department personnel who are familiar with these clues will be able to detect the presence of a hazmat through communication with field personnel. These six primary clues include occupancy and location, container shape, markings and colours, placard or label, shipping papers, and senses.

Emergency personnel should be aware of established locations in their communities associated with sources of hazmats such as chemical factories, laboratories, nuclear plants, vehicles transporting dangerous goods (DGs), reservoirs, and swimming pools. The Fire Services Department in Hong Kong maintains an updated database of the sites for storage of DGs. The shape and configuration of any container is a useful clue to the presence of a hazmat, for example, labelled fibreboard boxes, drums, and cylinders. Special containers, cargo tanks, rail tank cars, and other packages that carry hazmats may have special markings or colours. Usually the short form of the hazmat, identification number, toxicity, and special precautions will be printed on the container, for example '~~W~~' indicates 'dangerous when wet', and 'Oxy' stands for 'oxidizer'. Industrial hazardous substances are controlled by the United Nations hazmat system.[8] Hazardous toxic compounds are divided into nine groups, depending on their physicochemical and pathophysiological properties. Each substance has a United Nations code number that allows rapid determination of its nature and properties. In the US, CWAs are divided into four major groups according to FM 8-285 classification,[9] namely, pulmonary agents such as phosgene, blood agents such as hydrogen cyanide, blister agents such as sulfur mustard, and nerve agents such as sarin. The hazmat placards seen on transporters and buildings where hazmats are stored provide an immediate alert to the presence of a hazmat. Shipping papers should provide the shipping name, hazard class, identification number, quantity, and a 24-hour emergency contact telephone number. The senses of human beings can signal the presence of a hazmat. Vapour clouds, explosion, visual disturbance, bombs, abnormal taste, abnormal smell, irritation of the respiratory tract, shortness of breath, and irritation of the skin and eyes are indicators of the presence of a hazmat. Under these circumstances, it should be assumed that exposure has occurred and decontamination should be considered for the casualties. Common sense is also important for the early recognition of a hazmat incident. Binoculars are helpful for ascertaining visible information from a safe distance.

Initial assessment

The impact of a hazmat incident on the hospital should be assessed. The nature, date, and time of the incident, estimated number of casualties, and whether medical emergency teams are required to be dispatched to the incident site are important for decision making. In many clinical situations, the assessment stage is completed when a diagnosis is reached. Additional information, however, is important for the subsequent management of casualties involved in hazmat incidents. A convenient way to memorise the information can be summarised by the acronym 'ASBESTOS' (Box).[10]

Protection of staff and facilities

A hazmat incident can occur in any location, in urban or rural areas. Private vehicles or buses may transport casualties to hospitals in the vicinity of the incident.[11] Most of

The use of the acronym 'ASBESTOS' for memorising the subsequent management of victims injured in hazardous material incidents

- 'A' stands for what the hazardous agent is.
- 'S' stands for the physical state of that agent. Solids, liquids, and aerosols usually require decontamination. Decontamination, however, is usually not required for gas and vapour hazards.
- 'B' stands for body sites. Hazardous materials can be absorbed into the body via inhalation through the respiratory tract and direct contact with mucous membranes, eyes, skin, or wounds. This information will be useful to decide the type and level of protection required.
- 'E' stands for effect of the agent on the body. Both local and systemic effects should be noted.
- 'S' stands for severity. In the case of mass casualties, the hospital resources usually cannot cope with the demand. Triage should be exercised and treatment priorities applied in accordance with the severity of injury.
- 'T' stands for time course of symptoms. With chemical warfare agents, pulmonary and blister agents usually have delayed onset of symptoms, whereas blood and nerve agents will produce acute clinical effects. It is important to know the time course of the hazardous material incident to ascertain whether the casualties are in the acute or recovery phase as this can sometimes indicate the prognosis.
- 'O' stands for other differential diagnosis. Acute myocardial infarction may be precipitated because of the stressful conditions. Similarly, casualties of nerve agent attacks may be overdosing with the antidote (atropine).
- 'S' stands for synergism. It is important to note the possibility of the combined effects of multiple exposures or insults.

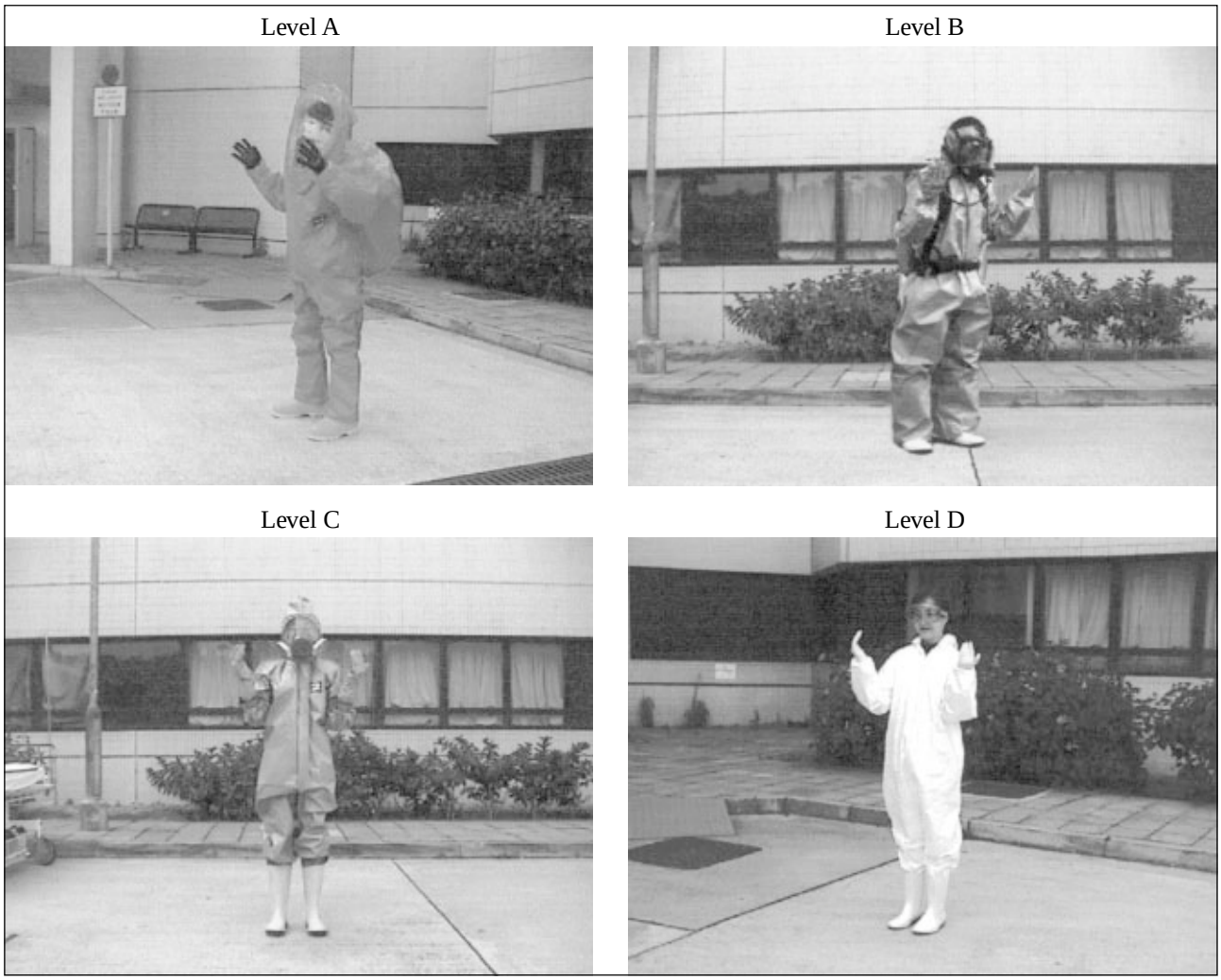


Fig 1. Levels A to D personal protective equipment

these casualties will not be decontaminated since the EMS is bypassed. If a hospital allows any of these casualties inside, the staff may become contaminated and become ill from the toxic exposure and the facilities may require closure for decontamination. Therefore, the hospital should be cordoned off. Casualties suspected to be contaminated should be directed to a contamination reduction zone for decontamination. Hospital staff involved in direct handling of hazmat casualties should be protected by appropriate personal protective equipment (PPE). Staff should be trained in the proficient use of PPE.

Levels of protection

There are four levels of personal protection for dealing with hazardous substances. These are described as levels A, B, C, and D for chemical protective clothing in combination with different types of respiratory protection.[12] Level A protection should be worn when the highest level of respiratory, skin, eye, and mucous membrane protection is needed. This protection consists of a fully encapsulated, vapour-tight, chemical-resistant suit, chemical-resistant boots, chemical-resistant gloves together with self-contained breathing apparatus (SCBA). Level B protection should be selected when the highest level of respiratory protection is needed, but a lesser degree of skin and eye protection is required. This equipment consists of a chemical-resistant suit, chemical-resistant boots and gloves, and SCBA. Level C protection should be selected when the types of airborne substance are known, concentration is measured, criteria for using air-purifying respirators (APR) are met, and skin or eye exposures are unlikely. This PPE consists of a chemical-resistant suit, full-face mask with air-purifying canister-equipped respirator, and chemical-resistant boots and gloves. Level D protection provides no respiratory protection and minimal skin protection and should not be worn on any site when respiratory or skin hazards exist (Fig 1).

Hong Kong Hospital Authority standard level C personal protective equipment

If the casualties arrive at a hospital alive, logically the concentration of the hazmat should not be high. Therefore level C protection should be adequate. For many occasions, hospital decontamination teams can operate with level C PPE.[13] The standard level C PPE adopted by the Hospital Authority for hospital decontamination teams includes

the following: a chemical protective suit with hood (Kappler Model, CPF2 2T426; Kappler Safety Group, Alabama, US), inner surgical latex gloves and outer chemical-resistant nitrile gloves (Ansell Model 37-175; Ansell Edmont Industrial Inc, Coshoton, US), chemical-resistant knee level boots with steel toe protection (Sermi Model 904; Rouchette SAS, Chapelle Rousselin, France), a full-face mask (3M Model 6800 series; 3M, Minnesota, US), and multi-vapour canister-equipped respirator (3M Model 6006; 3M, Minnesota, US). In the case of a biological attack, a particulate filter (3M Model 2091 P100; 3M, Minnesota, US) of a standard defined by the National Institute of Occupational Safety and Health (NIOSH) P100 will be adopted. This particulate filter can have 99.97% effectiveness in filtering particles greater than 0.3 mm in diameter. All accident and emergency departments in Hong Kong are equipped with 12 sets of level C PPE.

Agent identification

There are many types of hazmats throughout the world and new types of toxic chemicals are emerging. In order to obtain adequate information for a particular hazmat, a good updated electronic database is important. There are many CD-ROM hazmat databases available in the market such as TOMES Plus CD-ROM Database-Hazmat-Medical Information System (Micromedex Inc, Colorado, US) and Chemtox Database Software System (Resources Consultants Inc, Virginia, US). In the Hong Kong Hospital Authority, an on-line intranet-based 'ChemWatch'[14] database is available in 4000 clinical workstations, which are distributed throughout the hospitals. This database is regularly updated. Information such as physical properties, toxicity, clinical effects, first-aid treatments, levels of protection, antidotes, and clinical management is provided.

Decontamination of casualties of hazardous materials

The basic purpose of decontamination is to reduce or remove external contamination of hazmats from an individual. Personal decontamination refers to decontamination of oneself, casualty decontamination refers to decontamination of casualties, and personnel decontamination refers to decontamination of non-casualties.[15] Effective decontamination aims to make the patient as clean as possible, which means that the contamination has been reduced to a level that is no longer a threat to patients or responders. In order to protect staff and hospital facilities, all hazmat casualties are considered to be contaminated unless proven otherwise, and should be decontaminated before they are allowed to enter hospital areas. Hospitals should delineate an area for independently arriving hazmat casualties to undergo decontamination. Removal of clothing is the essential first step in the treatment of contaminated people. Once the clothing has been removed, 80% of the contaminant after liquid contamination and nearly 100% after vapour contamination will have been removed. This may be the only decontamination procedure that is required for those people exposed to a chemical gas or vapour or biological exposure.

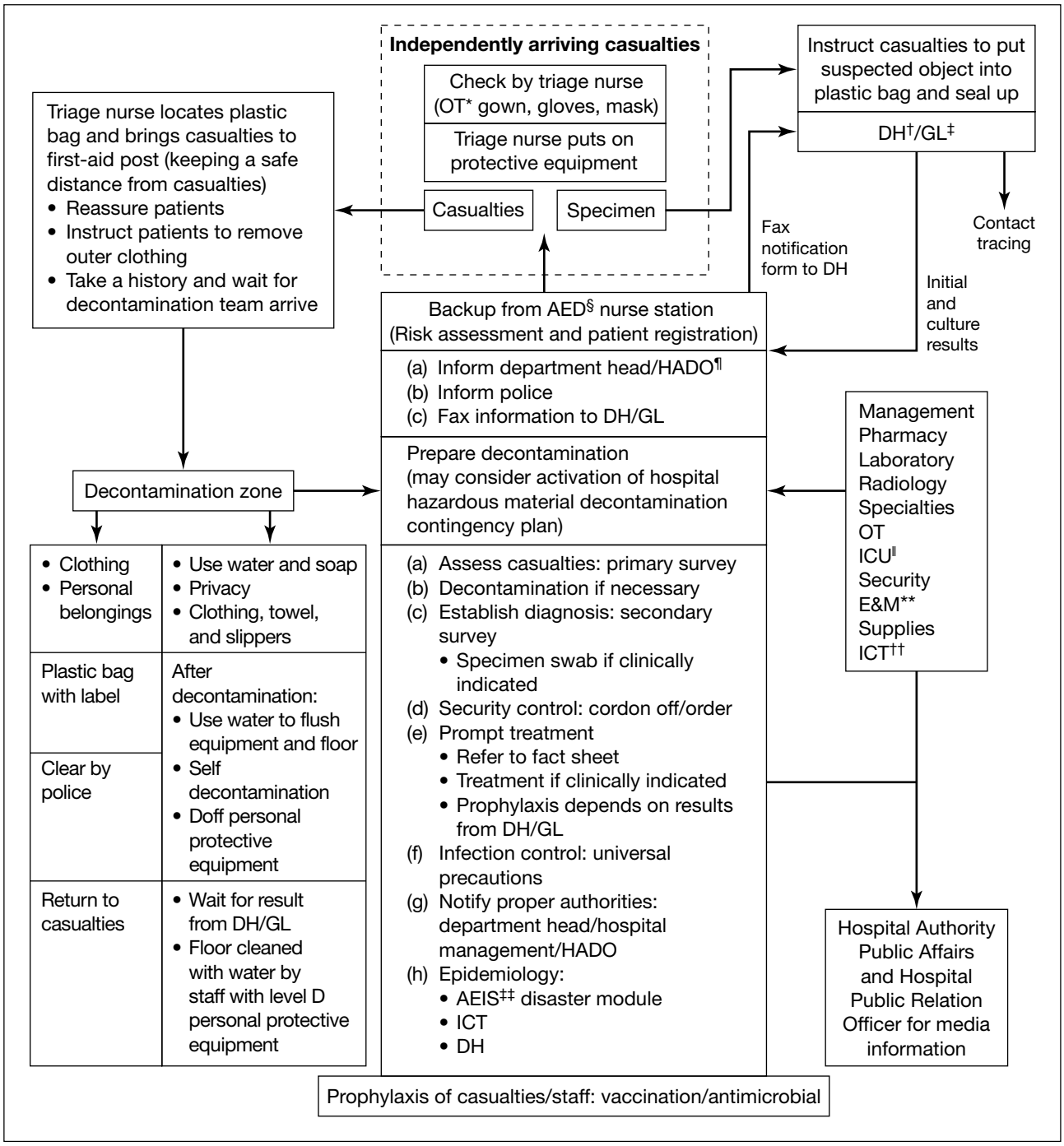
Fig 2. Portable decontamination shower

Decontamination facilities in accident and emergency departments in Hong Kong

All accident and emergency departments in Hong Kong are equipped with one portable 2 m x 2 m decontamination shower. This shower is made of chemical-resistant materials and can be assembled in 10 minutes. The decontamination shower consists of a basin and a four-sided curtain. There are two doors in the curtain—one for entry and one for exit. The function of the basin is to temporarily store the contaminated water, which is then pumped into a special container using an electric pump. A small foot-stand is placed inside the shower so that the person's feet will not be immersed in the contaminated water. An assembled decontamination shower is shown in Fig 2.

Approach to the independently arriving casualties of hazardous materials

Hazmat casualties may arrive at hospitals on their own. The normal EMS is bypassed and onsite decontamination has not been done. These casualties will be a risk for secondary contamination and could be hazardous to hospital patients, staff, and facilities. Therefore, hospitals with accident and emergency departments should have a contingency plan for responding to this group of patients. When a casualty enters an accident and emergency department, the first encounter will be with the triage nurse. A high index of suspicion and common sense will be important for early detection of these patients. When a suspect contaminated casualty is identified, the triage nurse should immediately notify all colleagues and then put on protective clothing, gloves, mask, and APR. This equipment should always be readily available in the triage station. The suspect contaminated casualty should be directed to a specified area outside the department, for example, a first-aid post. The casualty should be instructed to take off any



* OT operating theatre
† DH Department of Health
‡ GL government laboratory
§ AED accident and emergency department
¶ HADO Hospital Authority Duty Officer
‖ ICU intensive care unit
** E&M electrical and mechanical support team
†† ICT infection control team
‡‡ AEIS accident and emergency information system

Fig 3. Hospital Authority hazardous material contingency plan for independently arriving casualties

outer clothing and put them into a plastic bag. Before the arrival of the hospital hazmat decontamination team, the triage nurse should reassure the patient and obtain a brief history but keep a safe distance from the casualty (Fig 3).

The officer-in-charge of the accident and emergency department should decide whether or not to activate the hospital hazmat decontamination contingency plan. If decontamination is indicated, the casualty will be directed to the decontamination zone by staff dressed in level C PPE. All personal belongings will be placed into a labelled plastic bag. Copious amounts of water and soap should be sufficient for general decontamination purposes. The privacy of the patient should be respected. Warm water should be used in winter. If the condition of the patient is critical, life support measures such as Toxic Injury Advanced Life Support (TOXALS)[16] should be performed by staff who have been trained for this procedure. Toxic Injury Advanced

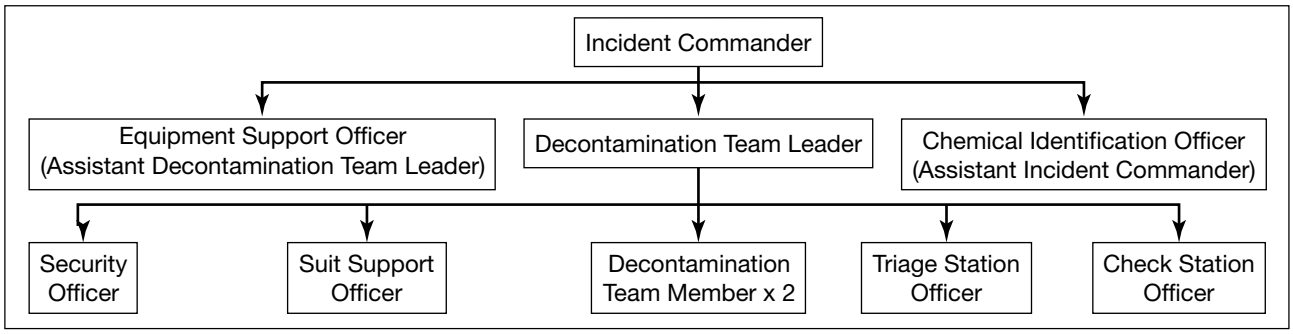


Fig 4. Hospital hazardous material decontamination team structure

Life Support may be defined as the application of advanced life support procedures in a contaminated or potentially contaminated environment by specially trained and protected emergency personnel.

Structure of the hospital hazardous material decontamination team

A team approach for decontamination is mandatory. To ensure staff safety, the decontamination team members need to be closely monitored and prompt support should be provided when required. According to the Hospital Authority hospital hazmat decontamination contingency plan (Fig 4), the team should consist of an Incident Commander (IC) who has overall responsibility for the incident management in the hospital. The Equipment Support Officer (ESO), Decontamination Team Leader (DTL), and the Chemical Identification Officer (CIO) will assist the IC in the management of the decontamination process. The ESO will set up the decontamination facilities in the contamination reduction zone. The CIO will perform computer search for relevant information with respect to the involved hazmat. The DTL will be responsible for supporting Decontamination Team Members, Security Officer, Triage Station Officer, and post-decontamination Check Station Officer. The Suit Support Officer will help the staff who require PPE.

Training of emergency personnel

Emergency personnel should be adequately trained before they can perform decontamination procedures. They should have fundamental knowledge of the clinical management of hazmat casualties. In Hong Kong, since 1999, a structured annual training programme has been organised by the Hospital Authority for staff working in accident and emergency departments. The training course consists of a practical approach for the management of hazmat casualties, common toxicological agents, triage concept, computer search for toxic materials, wearing PPE, and assembling the portable decontamination shower. The curriculum details of the course are shown in the Table. Since a hazmat incident is relatively uncommon, regular drills should be conducted. In order to keep staff familiar with these skills, a video-CD has been produced.

Conclusions

The risk of mass exposure to toxic substances has increased steadily during the twentieth century. The terrorist attack on the World Trade Center in New York City and the sarin attack in a Tokyo subway have indicated that such incidents can occur anywhere in the world. Although Hong Kong is a relatively safe place, it is not exempted from

Table. Hazardous material decontamination workshop for accident and emergency staff

Objectives	To train accident and emergency staff in hazardous material decontamination skills
Candidates per group	30
Curriculum (1 day)	
Understanding the common hazardous materials (hours)	
(a) Introduction	0.5
(b) Lectures on common hazardous materials	
- Chemical agents	1
- Biological agents	1
(c) Personal protective equipment and decontamination equipment	0.5
(d) Decontamination of casualties	0.5
(e) Triage of casualties	0.5
(f) Set-up of decontamination area	0.5
(g) Hospital hazardous material contingency plan	0.5
Practical session (hours)	
(a) Wearing of personal protective equipment	1
(b) Set-up of decontamination shower	0.5
(c) Computer search for toxicological agents	0.5
Assessment (hours)	
(a) Set-up of decontamination shower	0.25
(b) Wearing of personal protective equipment	0.25
(c) Multiple choice questions	0.5

such threats. Moreover, casualties of hazmat incidents may bypass the EMS and arrive at a hospital on their own. Accident and emergency department personnel should always be alert to the possibility that they may be dealing with a hazmat-contaminated individual. Recognition of hazmat, assessment of the conditions, protection of staff and facilities, identification of the hazmat, and subsequent decontamination are important elements in the formulation of a hazmat contingency plan. Hazmat incidents, although uncommon, will pose a major threat to the health of patients and hospital staff. Hospital preparedness is important for effective treatment of casualties and protection of staff against hazmat contamination.

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