Chemical, biological, radiological and nuclear considerations in a major incident

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Abstract

Chemical, biological, radiological and nuclear (CBRN) incidents have a disproportionate effect on all aspects of efficient management of casualties. The immediate risks to rescue and healthcare staff, along with damage and threats to existing infrastructure, make CBRN incidents an important consideration to plan and train for, even if the likelihood of encountering them is remote. In addition to the generic 'all hazards' approach shared with all major incident planning, CBRN incident management has a number of specific treatments and interventions which require early identification of the agent involved, and thus a high degree of specialist knowledge among responders.

Keywords Biological; CBRN; chemical; contamination; Hazmat; major incident; nuclear; pre-hospital; radiological; triage

The term CBRN stands for 'chemical, biological, radiological and nuclear', and relates to specific hazards that may be encountered during an incident. The term CBRN is generally reserved for the deliberate release of a hazardous material such as in a terrorist attack, whereas the term Hazmat is used for accidental release or exposure to toxic industrial material. Examples of some incidents that have taken place over the past 20 years are listed in Table 1. This article will use the term CBRN to relate to both deliberate and accidental exposure to hazardous materials.

The presence or even potential presence of a CBRN hazard in a major incident will make the management of the incident even more challenging for the following reasons.

- Increased risk to responder from on-scene hazards, as well as contaminated or contagious casualties. Unrecognized hazards may cause responders to become casualties themselves. For example: chemical suicide cases where the responder may become exposed to the chemical used, such as hydrogen sulphide.
- Increased risk or anxiety to the wider population. Industrial incidents may release plumes travelling beyond the conventional cordons and response zones. For example: Buncefield oil refinery smoke cloud crossed international borders.
- Responder's capability may be diminished due to personal protective equipment (PPE) such as chemical-resistant suits or gas-tight suits which require self-contained breathing apparatus (SCBA). PPE may significantly limit medical dexterity and communications while also causing physical and psychological stress.
- Increased mortality and morbidity of casualties. Unfamiliarity with the medical management of the CBRN agents may lead to delays in diagnosis and inappropriate treatment regimens.
- Increased number of psychological casualties. Bystanders and other members of the population may fear that they have been affected due to poor understanding of these agents. For example: radiation and the West African Ebola outbreak.
- Casualty processing is slowed down. Certain hazards will require casualty decontamination prior to the casualty being transported from the scene which will be resource, labour and time intensive.
- Management of contaminated wounds may affect surgical management. For example: contaminated wounds or local radiation injuries may need wider or repeated debridement compared to conventional wounds.

Consequently it is essential that all agencies and personnel that may be involved in a major incident response are aware of the additional problems that a CBRN threat can add.

Principles of CBRN medical incident management

The principles of CBRN incident management (SC_3AT_3ER) are:

- safety
- cordons
- command
- communications
- assessment (scene/casualties)
- triage
- treatment
- transport
- exploitation (forensics)
- recovery.

Pre-hospital responsibilities

In the UK, the fire and rescue service, police and ambulance services have robust plans in place to deal with major incidents including CBRN and Hazmat incidents. Regular training and exercises are conducted at regional and at national levels.

The fire and rescue service are responsible for tackling fires, dealing with released chemicals and hazard assessment, including detection, identification and monitoring (DIM), at an incident. They are also able to deliver a mass decontamination facility on scene should it be required. They will generally have the lead role at a Hazmat incident.

The police are responsible for coordinating the emergency services at an incident, to provide an effective outer cordon and to maintain public order. They will be the lead agency at a CBRN incident and will conduct appropriate investigations at any incident especially if there is loss of life.

The ambulance service have a dedicated hazardous area response team (HART) who can go forward into the inner cordon of a CBRN incident and perform triage and life-saving interventions. The ambulance service supported by a medical advisor will be the lead service with regard to medical matters at any incident.

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Example of CBRN, Hazmat and explosive incidents over the past 20 years

Chemical	Biological	Radiation/nuclear	Other
Deliberate	**Deliberate**	**Deliberate**	**Deliberate**
Sarin (Tokyo 1995)	Anthrax letters (USA, 2001)	Polonium-210 (London, 2006)	9/11 (USA, 2001)
Chlorine (Iraq 2007)	Ricin letters (USA, 2013)		London bombings (2005)
Nerve agent (Syria 2013)			
Chemical suicides (various)			
Accidental	**Natural**	**Accidental**	**Accidental**
Swimming pool over-chlorination	SARS (2003)	Fukushima (2011)	Buncefield oil refinery (2005)
Carbon monoxide incidents	Ebola (West Africa 2014)		

CBRN, chemical, biological, radiological and nuclear; SARS, severe acute respiratory syndrome.

Table 1

As with other major incidents it may be necessary for more advanced clinical care to be deployed to the scene. For example, a medical emergency response incident team (MERIT) may be required to assist with casualty assessment, casualty extrication and emergency medical treatment in a potential hazardous environment. In a CBRN or Hazmat incident it is likely that enhanced PPE will be required to be worn by all personnel within this area. Personnel likely to be called to such incidents need to be familiar with this equipment before attending the scene.

In-hospital responsibilities

It is a pre-hospital requirement for all casualties to be decontaminated before they arrive at the hospital. However in some circumstances, casualties in triage category 1 (**T1/IMMEDIATE**) may be conveyed before decontamination has taken place either due to a delay in recognizing the type of incident, or delay in decontamination due to the severity of the case. If there is a delay in the recognition of the incident or the deployment of pre-hospital decontamination units, there is a significant risk of contaminated walking casualties and well survivors self-referring to the hospitals.

As with any major incident the initial focus is on resourcing the emergency department (ED) with additional staff to cope with the large numbers of casualties that will arrive in quick succession. Clinical staff will be drafted from all areas of the hospital to work in and potentially lead resuscitation teams. All hospital staff that may be called to augment the ED response should be familiar with their local plans, have trained in the relevant PPE and be familiar with the processes of decontamination, as required. Although senior and specialist advice will be readily available for clinical decisions it is essential that all clinicians are able to identify certain signs and symptoms of chemical intoxication (toxidromes) (Table 2) but also be knowledgeable in the basic principles of managing casualties exposed to CBRN agents, including the use of antidotes.

The hazards

Initial assessment of the risk to individuals and the department should be based upon the toxicity of the substance involved; in general this can be broken into lethal, damaging, incapacitating and iatrogenic effects due to antidotes.

Chemical hazards

Chemical hazards are encountered daily both at home and in industry. The hazards they present cover a wide range of effects from lethality to mild symptoms. These substances include household chemicals, toxic industrial chemicals and chemical weapons. There is some overlap and the approach to any chemical hazard depends on its characteristics, as follows.

CBRN toxidromes and antidotes

	Nerve agent	Methaem	Cyanide	Pulmonary agents	Vesicant/acid/alkali	Atropine	Botulinum	Opiate
Consciousness	Fitting/↓	Agitated	Fitting/↓	Normal	Normal	Confused	Normal	↓
Respiration	↑↑	↑/↑↑	↑↑/Apnoea	↑↑	↑			↓
Eyes	Pinpoint	Normal	N/Dilated	N/Dilated/Painful	N/Red/Painful	Dilated	Dilated	Pinpoint
Secretions	↑↑	Normal	Normal	N/Frothy	N/↑			Normal
Skin	Sweaty	Cyanosed	Pink/Cyanosed	N/Cyanosed	Red/Blisters	Dry	Dry	Normal
Other	Fasciculations	Chocolate blood	Very rapid onset Lactic acidosis	Pink sputum	Mustard (delayed 6–12 hours)		Descending paralysis	
Antidote(s)	Atropine Oxime Benzodiazepine	Methylene blue	Nitrites Dicobalt edetate Sodium thiosulphate	? inhaled steroids	Lewisite – Dimercaprol Hydrofluoric acid – Calcium		Botulinum anti-toxin	Naloxone

Table 2