Personal Protection during Resuscitation of Casualties Contaminated with Chemical or Biological Warfare Agents—A Survey of Medical First Receivers

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Abbreviations:
APR = air purifying respirator
CBRN = chemical, biological, radiological, or nuclear
CBWA = chemical/biological warfare agents
HAZMAT = hazardous materials
PPE = personal protective equipment
SARS = severe acute respiratory syndrome

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Abstract

Introduction: The threat of mass casualties caused by an unconventional terrorist attack is a challenge for the public health system, with special implications for emergency medicine, anesthesia, and intensive care. Advanced life support of patients injured by chemical or biological warfare agents requires an adequate level of personal protection. The aim of this study was to evaluate the personal protection knowledge of emergency physicians and anesthetists who would be at the frontline of the initial health response to a chemical/biological warfare agent incident.

Methods: After institutional review board approval, knowledge of personal protection measures among emergency medicine (n = 28) and anesthetics (n = 47) specialty registrars in the South Thames Region of the United Kingdom was surveyed using a standardized questionnaire. Participants were asked for the recommended level of personal protection if a chemical/biological warfare agent(s) casualty required advanced life support in the designated hospital resuscitation area.

Results: The best awareness within both groups was regarding severe acute respiratory syndrome, and fair knowledge was found regarding anthrax, plague, Ebola, and smallpox. In both groups, knowledge about personal protection requirements against chemical warfare agents was limited. Knowledge about personal protection measures for biological agents was acceptable, but was limited for chemical warfare agents.

Conclusions: The results highlight the need to improve training and education regarding personal protection measures for medical first receivers.

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Introduction

The threat of mass casualties caused by a terrorist attack using unconventional weapons is a challenge for the public health system, with special implications for emergency medicine, anesthesia, and intensive care.[1–4] A key difference between the management of casualties contaminated by chemical/biological warfare agents (CBWA) and a conventional incident is that medical personnel are at-risk from contamination by the agent that caused the injury.[5] Therefore, CBWA injuries should be approached according to the experiences of accidental hazardous material (HAZMAT) releases and natural epidemics. Patients exposed to persistent and highly toxic CBWA should be decontaminated prior to arrival at the treatment facility in order to avoid secondary exposure and transmission of the agent to the medical staff. However, if immediate, individual life support and airway management are vital during such an incident, or if uncontaminated casu-

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		PPE 1 n (%)	PPE 2 n (%)	PPE 3 n (%)	PPE 4 n (%)	PPE 5 n (%)
SARS	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	2 (7)	24 (86)	2 (7)	0
Anthrax	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	4 (9)	18 (64)	6 (21)	0
Ebola	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	0	6 (21)	12 (43)	10 (36)
Plague	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	0	18 (64)	10 (36)	0
Smallpox	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	0	16 (57)	10 (36)	2 (7)

Table 1—Knowledge about biological agents (n = 28)
(Anaes: Specialty Registrars in Anaesthetics, n = 47, EM = Specialty Registrars in Emergency Medicine; PPE = personal protective equipment; SARS = severe acute respiratory syndrome)
Grey marking: current recommendation of precautions for first receivers[10]

		PPE 1 n (%)	PPE 2 n (%)	PPE 3 n (%)	PPE 4 n (%)	PPE 5 n (%)
Sarin	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	0	0	8 (29)	20 (71)
Hydrogen Cyanide	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	2 (7)	0	16 (57)	10 (36)
Phosgen	Anae	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	0	2 (7)	18 (64)	8 (29)
Mustard Gas	Anaes	0	4 (9)	34 (72)	7 (15)	2 (4)
	EM	0	0	0	18 (64)	10 (36)

Table 2—Knowledge about chemical agents (n = 28; Anaes: Specialty Registrars in Anaesthetics, n = 47, EM = Specialty Registrars in Emergency Medicine; PPE = personal protective equipment)
Grey marking: current recommendation of precautions for first receivers[10]

alties present themselves to the treatment areas, caregivers need appropriate protection. The deliberate sarin releases in attacks in Matsumoto and Tokyo provided important lessons for medical first responders and receivers. Fatalities at the site of the release essentially were caused by a lack of on-site resuscitation. Furthermore, the lack of control, training, and decontamination led to a number of secondary intoxications among prehospital and hospital medical staff.[6–9]

The aim of this study was to evaluate the personal protection knowledge of middle-grade emergency physicians and anesthetists who would be at the frontline of the initial health response to a CBWA incident.

Methods

Knowledge regarding personal protective equipment requirements among emergency medicine and anesthetic doctors was evaluated. After institutional review board approval, a standardized questionnaire was distributed to all residents with a minimum of three years of training in their specialty. A total of 28 emergency medicine and 47 anesthetic residents participated in the survey. Participants were asked for the recommended level of personal protection if a CBWA victim required advanced life support in the designated hospital resuscitation area. Knowledge regarding the following biological agents was tested: severe acute respiratory syndrome (SARS), inhalational anthrax, Ebola, plague, and smallpox. Although SARS is not known to be a weaponized agent, it was used as an indicator question for a recent natural epidemic. Furthermore, the personal protection recommendations for sarin, hydrogen cyanide, phosgene, and "mustard gas" (Di-chlor-diethylsulfid) also were asked. The indicator question was for a typical industrial hazardous chemical agent, hydrogen cyanide.

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The participants had to state what level of personal protection is required should one need to resuscitate an infected or partially contaminated patient.

The following personal protective equipment (PPE) was offered to the participants:

1. Healthcare uniform (i.e., scrubs) without specific protection;
2. Contact and splash/droplet precautions, (i.e., gloves, gown, surgical face mask, goggles (splash precautions));
3. Contact, splash/droplet and airborne precautions, (i.e., gloves, gown, particulate filter mask, goggles (airborne precautions));
4. Chemical resistant suit and full face air purifying respirator with filter (gas mask); and
5. Self-contained breathing apparatus and fully encapsulating, pressurized suit.

Each level of protection was explained further by a picture of the designated PPE. The anonymous questionnaires were collected and the answers were analyzed according to the current UK recommendations.[10]

Results

Participants expressed varying levels of knowledge of the recommended personal protection measures. The results are listed in Tables 1 and 2. The best knowledge within both groups was regarding SARS (86% emergency medicine group, 72% anesthetic group). Only a few participants over- or under-rated the recommended level of protection (over-ratings: 7% emergency medicine group, 19% anesthetic group; under-ratings: 7% emergency medicine group, 9% anesthetic group). A fair level of knowledge was demonstrated for anthrax and plague, with a high tendency to over-rate the level of PPE needed. In regards to smallpox, both groups displayed a fair level of knowledge (smallpox, 57% emergency medicine group, 72% anesthetic group, over-ratings: 43% emergency medicine group, 19% anesthetic group; under-ratings: 0% emergency medicine group, 9% anesthetic group). The most incommensurate level of knowledge was found for Ebola in the emergency medicine group, with a high tendency to over-rate the recommended level of PPE (79%).

The overall knowledge of the chemical warfare agents was less favorable: For the organophoshorous nerve agent, sarin, only 15% of the anesthetists and 29% of the emergency physicians stated the correct level of PPE, whereby 72% of the anesthetists under-rated, and 71% of the emergency physicians over-rated the recommended level of protection. Regarding the non-persistent agents phosgen and hydrogen cyanide, all participants over-rated the recommended level of PPE. The best knowledge was evaluated for mustard gas in the emergency medicine group (64% versus 15% for the anesthetic group).

Discussion

Injuries caused by CBWA always have been an unpopular topic for physicians.[11,12] Although the medical management does not significantly differ from HAZMAT incidents or natural epidemics, the frequency of these accidental incidents remains low. This can be attributed to the high health and safety standards in western countries. However, currently, the possibility of a deliberate release of toxic or pathogenic substances has been highlighted by many governmental and non-governmental healthcare specialists. Traditionally being seen as a military matter, the protection and treatment of CBWA victims have become a public health issue.

Individual protection measures during the airway management of patients with open tuberculosis or acute meningococcal infections are well known to medical first receivers. However, knowledge of protection measures against rarer agents or contaminants appears fragmented among healthcare providers.

In the UK, the Department of Health, the Home Office, and the Health Protection Agency provide healthcare workers with specially designed recommendations, standards of care, and protection, guidelines in the case of a deliberate CBWA release. One of the key features is the safety, protection, and decontamination of the responding medical staff.

As airborne, virulent biological agents may enter the body via the respiratory system, the majority of epidemic infections occur via the oral route. Therefore, splash precautions in the form of goggles, gowns, and gloves are the basic protective measure against non-airborne agents. If protection against airborne organisms is required, a correctly fitted, highly efficient particulate filter mask is necessary.

The presence of chemical warfare agents requires a higher level of respiratory protection, as these agents all have their greatest and most rapid entrance to the body via the pulmonary system and are not removed by particulate filter masks. Therefore, respirators unarguably are the first and most important line of personal defense against entry of CBWA.[13]

Respiratory protection in toxic environments can be divided as air supplying or air-purifying. Air-supplying devices provide the wearer with uncontaminated air from a pressurized tank. Despite offering the highest degree of protection,[14] their weight, limited air supply volume, and operational complexity restricts their use. The most commonly used respiratory protection devices are air-purifying respirators (APRs), with the wearer drawing air through an absorbent filter.[15] The filter canister will remove gases, vapors, and/or aerosols from the inhaled air, depending on the filter capacity and selectivity for various contaminants.[16] Modern APRs have been shown to be well-tolerated by anesthetists and paramedics during the simulated treatment of CBWA victims.[17,18] While showing their most rapid effects via the respiratory system, some chemical warfare agents are able to penetrate the skin. Under these circumstances, a chemical-resistant over-garment, in addition to a respirator, will protect the wearer from exposure.

Emergency physicians and anesthetists would be on the initial frontline of first receivers treating CBWA patients in respiratory or cardiac failure.[19,20] After being exposed to any persistent agent, patients should not be admitted to the emergency department without being fully decontaminated. Nevertheless, secondary sarin intoxications in the emergency department have been reported.[8] Following exposure to specific airborne biological warfare agents, patients might need to be isolated and treating staff would require ongoing protection. To ensure an adequate level of person-

al protection for the attending medical staff, guidelines have been published.[10,11,16,21] All protection guidelines are aimed to balance safety and comfort. For example, a fully encapsulating, gas-tight suit with a self-contained breathing apparatus would protect against SARS, but would put unnecessary strain onto the wearer, resulting in slow performance and early fatigue.

In 2004, Gould and colleagues emphasized that there had been no training or education for anesthetists in the UK that detailed measures that would be necessary to protect themselves, patients, and other staff members, let alone any specific treatment guidelines.[22] The authors felt "that at present it appeared that the issue is not being dealt with adequately at any level". According to the British Department of Health, 40,500 National Health Service staff have been trained between 2004 and 2007 to respond to major incidents (including chemical, biological, radiological, or nuclear (CBRN) incidents). A further 2,500 ambulance personnel also have received CBRN training, including those working in London's Hazardous Area Response Teams.[23]

In the current survey, the actual awareness of the current health and safety recommendations among specialty registrars was evaluated. The results show a reasonable level of awareness regarding SARS. This might be explained by basic medical knowledge and/or the long-lasting presence in the medical media following the SARS epidemic between 2002 and 2003. Knowledge about the person-to-person transmissibility of inhalational anthrax was surprisingly low despite the relatively recent anthrax attacks in the United States in 2001. The low familiarity with Ebola or smallpox might be explained by the rarity of outbreaks (the last documented cases of smallpox occurred in an outbreak at the University of Birmingham Medical School, England in 1978).[24] However, even if not allocating the adequate level of PPE, most of the participants realized that Ebola and (especially) smallpox have a high airborne contagion risk.

This survey is limited by the focus on the situation in the South Thames region and the lack of comparable data from other countries.

Conclusions

There is an overall reasonable level of knowledge regarding PPE for biological agents, but not for chemical warfare agents. A considerably limited awareness for PPE requirements against persistent and non-persistent chemical warfare agents or agents that also are absorbed through the skin was found. Despite considerable governmental efforts, these results highlight the need for further improvement in the training of medical first receivers regarding personal protection.

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