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Respiratory Protection for Health Care Workers

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ABSTRACT

Chemical, Biological, Radiological and Nuclear incidents are rare, but the likelihood of any medical facility having to deal with contaminated or contagious casualties is not, Health Care Workers (HCW) often being exposed to infectious or toxic substances. Although medical staff routinely take measures to protect themselves against exposure to infection by wearing protective clothing, they rarely consider the inhalational route as a threat. This paper presents a series of cases where HCW's have been exposed to toxic or infectious material through the respiratory route, discusses standards of respiratory protection and describes how this risk can be mitigated to protect medical personnel.

INTRODUCTION

Health Care Workers (HCW) are regularly exposed to infectious agents including viral illnesses, influenza, and tuberculosis. Less frequently they are exposed to toxic chemicals and occasionally to radiological contaminants. The main route of exposure to such agents is through inhalation. HCW's at particular risk include those who perform high risk respiratory procedures, such as anaesthetists and emergency physicians(1), those who assess and treat patients with undiagnosed fevers and respiratory illnesses, (junior doctors, emergency physicians and Nurse Practitioners) and those who are involved in the initial assessment and triage of casualties (receptionists and nursing staff).

As it is not always possible to identify those times when medical staff are likely to be at risk, this paper explores the concept that HCW's and allied colleagues should routinely consider the use of respiratory protection as the default setting when assessing patients with unknown conditions or unidentified contamination.

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CASE STUDIES

A series of real scenarios are presented as a means of illustrating the risks run by HCW's when managing a patient with an undiagnosed condition.

Norwalk-Like Virus in British Military Field Hospital, Afghanistan (2)

The index case, a soldier, presented having been on patrol. He was pyrexial, generally unwell and vomited whilst being assessed in the reception area of the Field Hospital. Shortly after this, between 13th – 19th May 2002 a total of 29 British personnel from the field hospital became acutely unwell with diarrhoea, vomiting and fever. The first three cases became very sick with gastrointestinal and neurological symptoms, two of these cases requiring intubation and ventilation. The hospital laboratory was unable to identify the causative organism, and because of the uncertainty and the severity of the illness 11 patients were evacuated to Europe. Three further cases arose amongst the medical staff either involved in transferring or caring for the casualties.

The infectious organism was later identified as Norwalk-Like virus (NLV). This organism is commonly associated with gastro-intestinal diseases and is common in health care facilities and on military deployments(2). NLV's are highly contagious, have a low infectious dose (<100 viral particles) and are associated with a period of asymptomatic viral shedding after recovery. The disease itself has a short incubation period of 24-48 hrs, presents with gastrointestinal symptoms, typically diarrhoea and vomiting and typically lasts 1-3 days. The virus is spread by the faecal oral route, particularly aerosolised or environmental contamination by vomitus(3). Although usually mild, more severe illness is not uncommon, and hospitalisation may be required for a number of cases. As aerosolisation provides such a rapid means of viral spread the use of simple respiratory protective measures would have protected the staff from contracting this disease and possibly prevented the outbreak in this instance(4).

Severe Acute Respiratory Syndrome (SARS)

SARS first appeared in Guangdong Province, China in November 2002, reaching a peak incidence in February 2003. It was initially reported as an atypical pneumonia. It is suspected to have been transferred to Hong Kong by a visiting Professor, where it resulted in an explosive outbreak of disease in a Hong Kong teaching hospital. The disease spread via air travel to over 30 countries, affecting over 7500 people and causing 573 deaths(5). HCW's are considered to be at particularly high risk, 41% of the cases in Singapore, 22% of the cases in Hong Kong and 74% of the cases in Canada were considered to be caused by contact in hospital or other health care facility. A cluster of over 60 probable or suspected cases were caused by a single SARS patient initially treated for gastrointestinal bleeding, kidney disease and diabetes.

SARS is caused by a novel coronavirus with an incubation period of around 10 days, and is probably spread via droplet or contact transmission(6, 7). It presents with a history of fever (>38°C), cough and dyspnoea and in addition there are X-ray changes of pneumonia or respiratory distress syndrome. HCW's are a high risk group due to their close contact with patients presenting with a non-specific "flu-like" illness. The situation was brought under control using strict infection control measures and in particular respiratory protection(8). Again the disease was spread by droplets. Respiratory protection played a crucial part in protecting medical staff and the standard of protection advocated (particularly in Canada) led to a decrease in transmission (9).

The Japanese Sarin Incidents

On the 27 June 1994 in Matsumoto, Japan, around 600 individuals were affected by Sarin gas released by the Aum Shinrikyo cult. 52 rescuers were also affected(10). On 20 March 1995 a second attack occurred on the Tokyo subway. There were 11 deaths and over 3,000 individuals reported to local emergency departments. In one emergency department, of the 15 doctors who treated casualties 13 were affected by symptoms of Sarin exposure, and six required atropine due to the severity of symptoms.(11) The large number of affected HCWs was due to the off-gassing of chemical vapour from the patients clothing caused by a lack of effective decontamination compounded by a failure to recognise the cause of the casualties' injuries. This was despite the similar event the previous year at Matsumoto(10) and intelligence that the threat existed in Tokyo. Once the diagnosis was made, patients could be correctly treated and staff appropriately protected. In this case the minimum respiratory protection required was a full face air-filtered respirator capable of absorbing the nerve agent. This would have provided protection from the systemic effects of sarin vapour and the local ocular effects (miosis).

Aluminium Phosphide poisoning

A patient presented to casualty in Australia(12), having been poisoned with aluminium phosphide tablets. These produce phospine gas on exposure to moisture. The patient was producing a foul garlic odour on arrival in the emergency department. Members of the resuscitation team began to notice symptoms of upper and lower airways irritation, and realised the source of the toxic substance was the patients exhaled breath. As the team were unprotected the resuscitation room was evacuated. The patient subsequently died

Ingestion of aluminium phosphide is a common way to attempt suicide in India, with up to 15,000 cases per year of which around 10,000 are fatal(13). In a six year period from 1997 to 2003 93 cases of Aluminium Phosphide poisoning were recorded by the National Poisons Information Service(14) in London. This case demonstrates the difficulties of managing a casualty without a diagnosis of the respiratory hazard, which took over 30 minutes to identify. As the hazard was unknown and difficult to detect, full respiratory and skin protection should have been mandatory. If this was available, the patient could have continued to receive full medical care from the resuscitation team without evacuating the facility.

Organophosphate Poisoning

Organophosphate poisoning is included separately from nerve agent poisoning, to demonstrate that this type of poisoning will be encountered in daily life and not solely following a terrorist attack with a war gas. Poisoning occurring in HCW's treating patients with self-poisoning with organophosphates has also been reported on several occasions(15-18) and although the cause of the symptoms described is not entirely without controversy(19) there was evidently some exposure to noxious fumes from the patient which led to the need to treat HCW's for secondary poisoning. In the paper by Geller(16) they report two cases of HCW's requiring atropine therapy after resuscitating a patient who had ingested an organophosphate. They had apparently been in contact with vapours off-gassing from the patient. Between 1987 and 1998 the National Institute of Occupational Safety and Health recorded 46 HCW's who had been affected after treating patients contaminated by organophosphates(16). These staff would have had full protection from a full face air-purifying respirator with an appropriate respirator canister.

The American Chemical Society (ACS) Chemical Abstracts Service (CAS) Registry contains over 21,000,000 organic and inorganic substances. The CAS Online Chemical Catalogues File (CHEMCATS) contained data on around 5,400,000 commercially available chemicals and their worldwide suppliers while the CAS Regulated Chemicals Listing Database (CHEMLIST) has data on over 229,000 regulated substances. There are known to be over 30 chemicals that can be used as chemical weapons and the toxic profiles of many agents is only partially or completely unknown.

RESPIRATORY HAZARDS

Medical staff are adept at performing risk assessments as part of their everyday tasks. They may not always be aware of the process, but undertake it never the less. There is, currently, a heightened awareness of the risks of cross infection from patient to patient by medical staff, but there is a lack of awareness of the risks posed by patients to medical staff from toxic and infectious materiel. The respiratory tract provides one of the most direct routes of exposure from toxic substances and staff remain unprotected from exposure by this route. Although the staff make assessments of risks to their patients they do not undertake the same assessment to risks to themselves. Dusts, mists, fumes, gases and vapours are all respirable as are particulate biological agents such as bacteria, viruses and moulds. The degree to which these particles are inhaled is related to factors such as their size, shape and density. There are no exposure limits, at present, for biological agents, so exposure should be as low as reasonably possible, but as there are no defined limits, no respirator or mask will provide guaranteed elimination of all risk.

Under health and safety legislation(20), employers are legally bound to protect their workforce from foreseeable hazards. The hierarchy of control describes the means of controlling risk by increasingly restrictive practices in order to protect an individual against a hazard, but starts with elimination of that hazard rather than protection against it(21).

Due to the nature of medicine, it is not possible to eliminate, substitute or enclose the hazard, and although under the hierarchy of control, protective equipment is one of the last resorts, if interpersonal contact is to remain, it is the only solution.

RESPIRATORY PROTECTION

Respiratory protection is usually provided by some sort of respirator. A respirator covers at least the nose and mouth of the wearer, and provides protection against inhaling airborne particles, gases or vapours. There are two basic types of respiratory protective equipment(21);

a) Air-supplied apparatus that provides an uncontaminated source of air, such as the Self-Contained Breathing Apparatus (SCBA) worn by firemen, or hose air supplied breathing apparatus that has an airline (Fig 1).

b) Air-purifying apparatus that filters or cleans contaminated air. This can be a powered device or a simple filter device.

Air-supplied apparatus has the advantage of a secure and safe supply that can be used in an oxygen deficient atmosphere, but the equipment is bulky and heavy and requires a significant amount of training, and there is a cost in terms of an increased burden to the operator, in comfort, communications, utility, acceptability and endurance. Air-purifying apparatus are lighter and easier to use, they are less of a burden to wear, but there value is limited by the ability of the filter to protect the individual from a particular hazard.

Other features that should be considered when choosing respiratory protection include:

- work rate
- wear time and rest periods
- medical fitness (of the HCW)
- visibility
- communications
- mobility
- contamination
- compatibility with other forms of protective equipment

Hazards encountered by HCW's include dusts, fumes, gases, vapours and biological particulates (bacteria, viruses and moulds). Prior to introducing respiratory protection, an equipment programme should be implemented.

A Respiratory Protective Equipment Programme should include(22):

- Identification of the hazards, and a risk assessment
- Fitness assessment
- Education and training of the workforce
- Maintenance, cleaning and storage programmes
- Regular monitoring and review

Choosing Respiratory Protection

Respiratory protection suitable for a chemical hazard requires, at the very least, a filter capable of adsorbing the toxic particle, fume, vapour or gas. Although there are adequate filters capable of dealing with chemical warfare agents (Nerve agents, vesicants, and lung damaging agents), there

Fig. 1 A Full Face Filtering Respirator

are practical difficulties in dealing with all toxic industrial chemicals due to their sheer number and differences in chemical natures. However a powered respirator system, such as the current NHS Personal Protective Equipment (PPE) incorporating a protective suit, provides adequate protection for most situations at the expense of acceptability and function (Fig 2).

Fig. 2 NHS Standard PPE

Respiratory protection suitable for biological hazards seems not to have been properly assessed or the risks conveyed to staff. Whereas normal or enhanced universal protections are sufficient to protect the skin from contamination, full respiratory protection requires an air-filtration device, with a particulate filter. A mask, such as a surgical mask, is designed to prevent droplets being exhaled by the wearer and is not intended to provide respiratory protection.

Respiratory protection devices are often given Assigned Protection Factors (APF). These cannot be used with biological agents as there are no exposure limits, however an APF does give an indication of the effectiveness of the respirator. There are two main EU Directives relating to PPE(23). These detail the basic safety requirements and the rules governing the provision of PPE for sale. In addition the standards required for Particulate Respirators are laid down by law(24) whilst BS EN149/2001(25) outlines the selection of devices and assesses their limitations and appropriate usage. All respirators are tested against solid and liquid aerosols (using sodium chloride as a marker for solids and Paraffin oil as a marker for liquids) and there are three classes of protection assigned to the filtering face pieces (a filtering mask made up of filtering

Fig. 3 A simple filter mask

material), (Fig 3).

FP1, FFP2 and FFP3. The higher the protection factor, the higher the respiratory protection afforded. Protection is dependant on the proper use of the respirator, a proper fit and the use of suitable other precautions.

Discussion

There is a balance to be drawn between providing a comfortable and socially normal working environment for patients and staff and controlling exposure to potential respiratory hazards.

Since the Japanese Sarin nerve agents attacks and the increase in real or perceived risk from terrorist chemical weapons, staff and public are used to the idea of chemical protective suits. Because of the difficulty in diagnosing chemicals hazards and the myriad of chemical agents that could be encountered, the management of chemical agents requires an all risks approach with full protection of exposed staff, including full respiratory protection, with life saving first aid provided during decontamination, which should occur in a safe area. Once the casualty is considered clean, respiratory protection can be reduced or discontinued depending upon the risk.

It is clearly possible to detect certain toxic substances, such as nerve agents and mustard gas using chemical agent monitors. However, there are problems with the technology, the multitude of toxic material and the fact that some agents (such as mustard gas and some nerve agents) will produce health affects at levels below those that can be detected by chemical detectors. The cost of providing chemical agent monitors to all health care facilities (and complete the necessary training in use and maintenance) would be excessive.

Biological hazards are a different matter. Fever and respiratory illness are an everyday occurrence within health care facilities. It would be impracticable and socially unacceptable to staff and patients for HCW's to adopt the all risks approach of chemical agent management. The risk profile is also different, with the main threat coming from inhalation rather than skin contact.

As such respiratory protection with a simple filtering respirator, coupled with normal protective clothing should be sufficient to safeguard the health of HCW's whilst they are assessing and treating high risk patients.

The minimum standard should be a respirator that complies with BS EN149:2001 FFP3 as discussed above(25). If high risk diseases are suspected then a higher level of respiratory protection should be the norm, such as SCBA. In Canada(26), the standard is a filter capable of filtering one micron particles, with 95% efficiency and a tight facial fit, this standard is met by the N 95 NIOSH (National Institute of Occupational Safety and Health) approved respirator(27,28). Certain anaesthetists have concluded that in addition to an N95 mask further protection is provided by using a powered respirator with a high efficiency particulate filter (HEPA) providing continuous clean air driven down across the wearers face. This system provides over 98% protection at 0.3 microns at 180 litres per minute(29).

The Health Protection Agency advice is currently for respiratory protection for suspected cases of SARS. With the possibility of a new influenza epidemic from avian flu, respiratory protection should be considered the norm when dealing with high risk patients. (See box 1).

High Risk Patients

- Chemical exposure
- Contact with known case of highly infectious disease
- Fever >38°C
- Undiagnosed respiratory illness
- Productive Cough or Cough with other respiratory symptoms

Box 1 High Risk patients for whom respiratory protection should be worn

Those most at risk, such as HCW's in austere environments and those dealing with undiagnosed infection, particularly tropical diseases, should give particular attention to respiratory protection. Medical aid agencies, refugee workers, and the military would appear to be at particular risk. In all modern conflicts disease infections or "non battle injury" rather than trauma has accounted for the majority of military casualties. HCW's are at the fore front of this battle.

Summary

HCW's are at risk of inhalation of chemical and biological hazards. The management of chemical hazards requires strict protocols and attention to detail. HCWs have received training in the handling of these situations, and procedures should be in place in all hospitals to cope. However, the increase in terrorist activity, the SARS epidemic, the threat of avian flu and the possibility of other diseases presenting unexpectedly to health care facilities suggests that the need for respiratory protection should be reassessed. Since the SARS outbreak, the Health Protection Agency, the US Centers for Disease Control and prevention and other agencies (such as the Canadian Authorities) have advised that HCWs should wear filtering face pieces. SARS arrived out of the blue, Avian Flu may arrive at any time, and if it does not, another biological disease is bound to occur in time. The threat of biological terrorism is real and will occur when least expected. It seems only sensible and fair to conduct a proper risk assessment and institute a respiratory protection programme to protect all HCW's at risk of exposure to undiagnosed chemical or biological agents.

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