The role of the anaesthetist during biological, chemical or nuclear incidents

Introduction
Use of biological and chemical weapons are not new. These weapons have been used during the Peloponnesian War in 423 BC where soldiers lighted coals and sulphur, pitching them into their opponent’s forts. Biological warfare dates back as far as the 14th century. Tartar forces catapulted their plaque-infected corpses into the shelters of their Kaffa enemy. A plague outbreak led to the retreat and conquerance of Kaffa (now Feodossia and Ukraine).2,3

Weapons with the potential of major population insult, may be in the form of biological, chemical or nuclear devices.4 The rapid proliferation of nuclear weapons, ease of attainment of chemical agents and rapid international transportation of chemical materials all increase the relative availability of these deadly agents, making it more likely to be used by radical groups.5 Furthermore some countries have stocked nerve agents, and this still presents a threat to civilian and military populations.6,7 These weapons need not be sophisticated to be extremely effective, resulting in major loss of life and life limitation. As a result, World Health Organization (WHO) states have on several occasions agreed that the development, production and use of biological and chemical weapons be prohibited. International treaties have been signed by committed countries,6 underlining their strong feelings not to use these weapons. Sadly, not all have done so and non-member states may use these weapons for terrorism.

Anaesthetists and intensivists manage critically ill patients on a regular basis8 and should be able to respond with immediate and continuing life support to victims of these agents.9 They have an excellent range of knowledge including physiology7, pathophysiology8, pharmacology4 and physiological and hemodynamic monitoring7, making them ideal as part of the initial emergency response team when a biological, chemical or nuclear incident occurs. Their knowledge is also invaluable in long-term management planning.6 The increased role of the anaesthetist will inevitably enhance the risk of exposure to an agent of war, necessitating the need for training in protection and decontamination procedures.

CHEMICAL AND BIOLOGICAL AGENTS

Chemical agents of warfare are used because of their direct toxic effects on man, animals or plants. They may be in gaseous, liquid or solid form. Chemical weapons are classified according to their intended target and physiological effects.

Blistering agents [Mustard gas, lewisite (arsenics)]
These agents are liquids causing blistering and chemical burns to all epithelial tissue. Systemic manifestations following inhalation or ingestion include respiratory failure, blindness, vomiting, pancytopenia and teratogenicity.6

Mustard gas
Mustard gas causes no initial eye irritation and smells faintly of mustard, garlic10 or onion. Acute effect starts within 4-12 hours post-exposure, and diffuse erythema occurs in exposed skin with oedema and 1st degree chemical burns. Eighty five percent of patients have reported eye problems recovering over weeks after sloughing of the cornea. Tracheobronchitis follows several hours after exposure in 70% of victims. Bronchospasm is common. Airway collapse and pulmonary haemorrhage, and oedema with secondary infection are factors that mandate intensive care admission and ventilation. Bone marrow suppression occurs after high dose exposure and leukocytosis is followed by leukopenia. No topical antidote has been formulated yet.6

Nerve agents (Sarin, Tabun, Soman, VX)
All of these are structurally related to organophosphates and inhibit acetylcholine-esterase enzymes irreversibly. These are extremely toxic, colourless, odourless and tasteless. Intoxication results in a cholinergic crisis, respiratory failure and polynuropathy.6

Choking agents (Chlorine, phosgene, chloropicrin)
These agents are highly volatile and inhalation leads to irritation of the eyes and nasopharynx with severe cough and dyspnoea. Early respiratory distress and toxic pulmonary oedema develop, followed by respiratory failure. Many of those who survive will suffer permanent lung damage.6

Blood agents (Hydrogencyanide)
The effect is caused by the decrease of cytochrome oxidase and other enzymes. Convulsions and cardiorespiratory arrest follow the metabolic acidosis and tissue hypoxia. Hydrogencyanide is a colourless liquid and has the smell of almonds, which proves to be fatal within 15 minutes following intake of a lethal dose.5

Toxins (Saxitoxin, ricin, botulinum)
These are severely toxic chemicals. They are biological products produced by living organisms, but their effect does not require replication in humans. Botulinum toxin by weight is the most toxic chemical known to exist.24 Permanent inhibition of acetylcholine release, leads to acute febrile descending paralysis and varies from mild to dense plegia all over.2

Teargas and harassing agents (CS gas, capsaicin spray)
These are sensory irritants, the effect being the temporary incapacitation of affected individuals.
BIOLOGICAL AGENTS

Biological agents are living organisms, intended to cause disease or death in man, animals or plants. Their effects depend on their ability to multiply in the host attacked.6

Bacteria

[Bacillus anthracis (anthrax), Yersinia pestis (plague), Francisella tularensis (tularemia)]

Bacteria are easier to cultivate than viruses, highly effective and could be lethal.

Bacillus anthracis (anthrax)

This is a very resistant gram negative spore forming bacterium, making it ideal for biological warfare. Anthrax may present as one of three clinical pictures, a cutaneous infection, gastrointestinal disease or inhalation symptoms. The cornerstone of treatment is early antibiotic administration of penicillin, doxycycline or ciprofloxacin, but anthrax has been bioengineered to be resistant. A vaccine, Michigan vaccine, is available.6 Anthrax was spread in the United States during Oct. 2001, with eleven people developing inhalational anthrax, five of them died. Seven confirmed cases of cutaneous anthrax were reported. Thirty thousand people received prophylactic antibiotics.5,9

Yersinia pestis (plague)

A gram negative bacterium. The vectors are fleas. The infection spreads with droplets, human-human, and animal-human. Infected patients develop malaise, fever, myalgia, pneumonia, hemoptysis and sepsis. Patients eventually need mechanical ventilation and organ support. When released as war agent these bacteria will be infectious for approximately one hour.5

Viruses

[Variola virus (smallpox), Haemorrhagic viruses, Viral encephalitis]

These agents are highly infective and often lethal.

The last case of smallpox was reported in Somalia in 1977. The WHO declared smallpox as eradicated in 1980. New, more virulent and contagious strains have been bioengineered and possibly stockpiled.3 People are not being vaccinated any more, making the population more susceptible if smallpox viruses are released. Mortality rate may be as high as 30% in those not vaccinated.9

A wide range of possible viruses is available for inducing haemorrhagic fever. All are highly infectious and mortality rate may be as high as 90% even after treatment.6

PRIMARY RESPONSE (Prehospital)

Anaesthetists are comfortable when managing a patient’s airway and during management of a patient being ventilated. They are also well trained regarding decisions on patient admission into critical care, post-operative sedation and chronic pain management. The initial problem may be that the anaesthetist, being in the field as primary care provider, is removed from his/her normal work-place comfort zone and certain tasks that are not regularly performed must be done.10

Triage, movement and decontamination of mass casualties are essential in the primary situation and specific training should be part of the preparation for such an event.11

The key to treatment of casualties from agents of chemical, biological and nuclear war (CBNW) is to identify the agent used, understand the physiological effects, and strategise a rapid decontamination programme and response plan.10 All personnel in the primary response team are at increased risk of biological or chemical contamination.7 The golden rule for any care provider is clearly stated as one of the Ten Commandments for Medical Management of a Biological Attack of the United States Army Medical Research Institute for Infectious disease:

“Thou shalt protect thyself” 54

Safety for the anaesthetist, personnel and other patients comes first.

The initial medical response following the release of a nerve agent is the immunisation and prophylaxis of people, as well as antidote therapy for those in contact with the agent.13 Patients should be evaluated acutely and sent for decontamination. Decontamination prior to hospital admission dramatically reduces personnel contact with CBW agents. Some patients will need urgent basic life support before being sent for decontamination, and skilled personnel are necessary to make these decisions. Patients should be evaluated for possible exposure, trauma, risk for others and survivability.40 We as anaesthetists will be able to evaluate these patients quickly and correctly and provide the necessary care needed. Those patients who need further management have to be decontaminated immediately and if not possible, triage to an allocated protective area should take place. The hazardous material (HAZMAT) system provides important guidelines for these situations.4,6,9 The basis of airway, breathing and circulation is still the cornerstone of approach.15 These toxins alter the respiratory system in various ways as described above. Specially designed ventilators have been manufactured for these situations, providing oxygen within a toxic environment. 10,17

Patients who are exposed to chemical agents will be decontaminated more successfully than those infected by biological agents. Patients and personnel may require vaccination and prophylactic antibiotics and isolated nursing and care, making it problematic in the acute situation.4

Life-saving treatment may well be necessary before decontamination, especially by those within the initial response team.

SECONDARY RESPONSE (Hospital and medium term treatment phase)

Nuclear weapons do cause immense destruction and are therefore named weapons of mass destruction. Biological and chemical weapons have recently been classified as weapons of mass injury.6,14 The mortality rate following chemical agents has been shown to be 3-5%12, but a high morbidity rate follows such an attack. This implies that many patients following a chemical or biological attack will be in need of emergency medical care. The number will also increase when such an attack is associated with strategic bombing or missile fire. Ballistic delivery systems have been developed and the likelihood of chemical exposure as well as conventional injuries requiring emergency life-saving surgery, are further increased.3 Many of these patients will be in need of acute treatment and possibly long-term postoperative intensive care management. The medical resources will be overwhelmed and the patient load may be impossible to handle within local medical facilities.14 Hospitals were overwhelmed following the 1995 nerve gas release in Japan. Five thousand five hundred people required treatment and 11 died.10 This again highlights the importance of triage.

Children are more likely to be affected by these agents as nerve agents are more concentrated at ground level because of a higher density than air.9

Except for the direct effects causing trauma, such an incident has a severe and far reaching ripple effect. Morbidity also increases because of complications secondary to the incident. It was shown that
morbidty in Israel during the Gulf War was increased dramatically because of secondary causes. Motor vehicle accidents increased, with 2340 injuries and 45 deaths. There was an increase in myocardial infarctions and dysrhythmias as well as an increase in cerebrovascular accidents. Seventeen people suffocated because of improper mask use. Another factor to remember is that people inject themselves with atropine when contact with a nerve agent has occurred. Two-hundred and twenty six patients were seen with tachydysrhythmias and other atropine like side effects. All these factors increase the load on medical facilities and personnel, necessitating competent and skilled personnel in the primary and secondary response team.

**PERI-OPERATIVE ANAESTHETIC CONSIDERATIONS**

The anaesthetist is more at home in theatre, but getting a patient exposed to biological and chemical agents safely through an anaesthetic and surgery can be extremely challenging. Those exposed to a biological agent are most probably infective to all in close vicinity, as these patients cannot be decontaminated to the same extent as those exposed to chemical agents. Every organism has its own unique clinical presentation and systemic complications, and this will not be discussed here.

Patients with chemical agent contact are problematic in terms of anaesthetic approach. Nerve agents have physiological and drug interactions, altering the normal anaesthetic course. The main concerns are respiratory problems including respiratory arrest, excessive secretions, severe hypoxia and decreased uptake of inhalation agents due to ventilation/perfusion imbalance. Cardiovascular complications include an initial cardiac overstimulation lasting a few minutes, followed by severe cardiac depression lasting a few hours. Patients may also be severely dehydrated because of excessive fluid loss and not being able to replace the increased needs, making them more cardiovascularly unstable. Dehydration is also problematic for those dressed in protective clothing because of severe sweating.

Neurological effects include convulsions, coma and head injuries. Patients exposed to nerve agents (organophosphates) may have prolonged effects following succinylcholine and non-depolarizing agents administration. Prolonged post-operative ventilation may be needed. This is usually easy to handle if one or two patients have these symptoms, but a difficult situation arises with many hundreds of patients requiring urgent ventilatory support. Only well trained personnel can take part in this kind of decision making i.e. who will be ventilated and who not.

Drug interactions: United States soldiers will be given pyridostigmine as prophylaxis if the possibility of exposure to nerve agents arises. Self-administration of atropine is being taught, following exposure to a nerve agent. The anaesthetist will most likely see some of these patients in the theatre, pretreated with pyridostigmine or atropine. Patients may present with tachydysrhythmias following excessive atropine administration. Pyridostigmine causes delayed gastric emptying, possible bronchospasm and increased sensitivity to non-depolarizing muscle relaxants.

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**LONG-TERM EFFECTS**

Patients will be seen in theatre for many years following such a catastrophic event. Many will have developed long term complications, creating new challenges for the anaesthetist. Long-term effects may include chronic illness, delayed effects, effects mediated by ecological changes and a resulting endemic because of biological agent release.

Blistering agents have the capability to cause permanent lung damage, including pulmonary fibrosis, asthmatic bronchitis, chronic bronchitis, bronchiectasis and large airway obstruction. People are still dying from pulmonary complications 12 years since exposure. Blindness follows delayed keratitis, and dry itching skin leads to multiple chronic skin disorders.

Brucella melitensis as biological agent may also cause chronic illness. Endocarditis, joint pathology, chronic fatigue and depression are frequently seen. Francisella tularensis infection results in weakness and fatigue, lasting many months.

Delayed effects include carcinogenesis, teratogenesis and mutagenesis. Mustard gas has been shown to increase the incidence in cancer of the respiratory tract. Other agents lead to the development of leukemia and lymphoma. The rubella virus is well known to cause fetal abnormalities.

Biological agents may result in a disease becoming endemic. Salmonella, Shigella or Bacillus anthracis may become a prolonged pathogen in an environment or population.

Human health will be effected to the negative if such an event causes a change in the ecology. Quality and quantity food is necessary for humans to be healthy and will be affected to the negative with such an ecological disaster.

**SUMMARY**

We as anaesthetists are in the unique position of assisting patients who will depend on skilful medical care when they need it most. The acute airway and circulation management is well in the scope of our profession, but further training is needed in the field of self-protection, triage, decontamination and transportation of exposed patients.

The South African Defence Force presents biological and chemical warfare courses, open to the public. From this paper it can be seen that we lack knowledge of the bigger picture in handling such a major threat. We should actively increase our working knowledge about handling such disasters, working as part of the team.

The local medical facilities (which we should be part of) should be more focused organizing a working plan in case of such a catastrophic episode. The personnel of 30 British Hospitals did not feel capable of handling a chemical or biological event. How do we rate our local facilities? Is there a security plan in place at our facilities? A more direct question: Do we have protective equipment for hospital personnel and ourselves in our hospitals? (A face mask and latex gloves only, are definitely inadequate protection.)

The question to be answered from this lecture: Are we as anaesthesiologists ready and capable to be part of such a team? The answer remains a conclusive NO. Although we have a lot to offer, we still have a lot to learn.

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