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Biochemical Terrorism: What the Anesthesiologist Should Know

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Although the chances of a biological or chemical attack occurring in Canada are slim, the consequences of such an attack could be devastating. As a result, it is very important for anesthesiologists to have a basic understanding of the various biological and chemical agents involved, and the appropriate treatments. For each type of agent, there are fundamental rules that apply. Biological agents include anthrax, plague, botulism, tularemia, and smallpox, while chemical agents are neurotoxins, cyanogens, pulmonary agents, and vesicants. In the event of a massive attack, demands for treatment would exceed available resources. Physicians in charge would have to carefully triage victims to optimize treatment capacity and thereby increase patients' chances of survival. In addition to the trauma caused by the agents, there is also the necessity of providing adequate psychological support because many of the victims will have symptoms of response similar to combat stress. This issue of *Anesthesiology Rounds* reviews the background to biochemical warfare, the potential agents involved, procedures of decontamination, and the processes of triage.

INTRODUCTION

Bioterrorism is defined as the use of microorganisms with the deliberate intention of infecting a predetermined population in order to achieve certain goals or objectives. Chemical terrorism is defined as the use of chemicals with the deliberate intention of causing illness in a predetermined population in order to achieve certain goals or objectives.

Since these microorganisms and chemicals are easy to obtain, cheap to produce, and very hard to detect, biological and chemical terrorism could become weapons of choice in the future. Although the chances of this type of attack occurring in Canada are slim, if one did, the consequences could be devastating. According to Center for Disease Control (CDC) estimates, under certain conditions, an anthrax attack on a population of 100,000 Canadians would result in 50,000 anthrax cases or one out of every two persons, 32,875 deaths, 332,500 days of hospitalization, and a cost of $6.5 billion.

In the face of such possibilities, anesthesiologists should know how to effectively treat the victims of this type of attack. This knowledge extends to several areas including decontamination and victim triage, the protection of medical personnel, recognition of the symptoms, and the proper medical treatment for each agent that might be used.

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BACKGROUND

During World War I, it was discovered that the use of certain chemicals (cyanogens, phosgenes, and mustard gas) increased the number of injured and was, therefore, a formidable weapon. During World War II, the German army developed neurotoxins. In the 1970s, the Vietnam government used them against Cambodia. In the 1980s, the Russians deployed them against Afghan rebels. More recently, Iraq engaged in chemical warfare against the Kurds. In the 1990s, a sarin gas attack occurred in the Tokyo subway. Lastly, in 2001 there were anthrax attacks in the United States. Unfortunately, one can expect these types of attacks to increase in the future.

DECONTAMINATION AND PROTECTIVE GEAR

Decontamination is essential. Its purpose is to stop absorption by the victim of an attack, as well as to prevent the contamination of medical equipment and personnel, thereby keeping the number of victims from climbing. Failure to decontaminate victims can only aggravate the situation and add to losses of equipment and personnel. Therefore, every patient suspected to have come into contact with a chemical substance or biological agent must be decontaminated before receiving actual medical treatment in any establishment.

In the case of biological agents, decontamination is minimal and involves undressing the patient and applying the infection control procedures in effect at the healthcare centre. With chemical agents, however, decontamination is essential. Rule No. 1 is to protect the personnel doing the decontamination. This protection involves wearing a gas mask that protects against pesticides, impervious or Tyvek protective coveralls, butyl gloves, and rubber boots. The second rule is to undress the patient and put all their clothing into a trash bag, and then wash the victim with soap and water in a bath or shower. After that, the patient can be moved to a treatment room in the hospital.

It is also important to remember that the decontamination zone should be located as far as possible from ventilation ducts. Moreover, it is absolutely essential to keep any person or object that has not been decontaminated from entering the rest of the hospital. Personnel working in the decontamination zone must be prepared to administer antidotes, if needed (eg, atropine and 2-PAM).

TRIAGE

These situations produce a number of patients whose needs exceed available resources. This makes it essential to do an efficient triage in order to optimize the care given, as well as, the number of survivors.

Patients are divided into 5 groups that represent how urgently they need treatment:

- P1 (immediate treatment): These patients are nonambulatory and need treatment as soon as possible. Their lives are in danger.
- P2 (delayed treatment): These patients require medical treatment, but it can wait. Their lives are not in any immediate danger, but that could happen later.
- P3 (minimal treatment): These patients are ambulatory and require a basic examination. They are conscious, breathing spontaneously, and have adequate tissue perfusion.
- Dead: Patient dead on or after arrival.
- Psychogenic: These ambulatory patients show no signs of a physical attack, yet, display various symptoms. For example, in the 1995 incident in Tokyo, the ratio of psychogenic to poisoned victims was 5:1.

EXAMPLE OF FAST TRIAGE

- Is the patient ambulatory? If so, the patient is a priority 3.
- If not, is the patient breathing spontaneously? If not, are the airways blocked? If not blocked, the patient is dead.
- If breathing spontaneously, what is the respiratory rate? If <10 or >30 breaths/minute, the patient is a P1. If the respiratory rate is between 10-30/minute, the patient is a P2.
- Next, check circulation by measuring the pulse and capillary return. Is the pulse <50 or >120 beats/minute and/or capillary refill >2 seconds? If so, the patient is a P1; if not, a P2.

BIOLOGICAL AGENTS

The ground rules: recognize, inform, decontaminate, and treat. It is vital to recognize the possibility of a biological attack if there is a sudden increase of

illness in a previously healthy population. Both humans and animals are stricken, and a higher incidence of the illness is found in a particular geographic area or timeframe. This can take the form of a sudden increase in a nonspecific syndrome such as pneumonia, influenza episodes, fever, coagulation disorders, unexplained skin or mucosal rash or irritation, and neuromuscular disorders.

If the signs prove positive, the next step is to inform by notifying management at your establishment as well as public health officials. It is important to run diagnostic tests and activate the emergency measures plan. Remember that decontamination is usually not necessary for biological agents. It is necessary, however, to undress the patient and place their effects in a trash bag. Your establishment's infection control procedures should also be applied.

Anthrax

The causal agent is *Bacillus anthracis*. Transmission is by inhalation, ingestion, or through the skin. It is not communicable from person to person. Infection control procedures must be applied. The incubation period averages 2 to 6 days, but may be as long as 8 weeks. The diagnostic tests are Gram's stain, blood agar culture which reveals the presence of Gram+ bacilli, and ELISA.

The signs and symptoms mimic an influenza episode with fever, pneumonia, and sudden dyspnea. A lung X-ray reveals a mediastinum enlarged by adenopathies. On the skin, pruriginous papules appear first, followed by ulcers that are painless and necrotic in the middle.

The treatment combines ventilatory support with antibiotherapy (ciprofloxacine 400 mg IV q8-12h or doxycycline 200 mg IV initially, then 100 mg IV q8-12h). The recommended preventive treatment is ciprofloxacine 500 mg po bid or doxycline 100 mg po bid. Amoxicilline is preferable for pregnant women and children.

Plague

The causal agent is *Yersinia pestis* and transmission is by inhalation. Only the pulmonary form of the disease is communicable from person to person. In addition to the usual precautions to prevent infection, protective measures must be taken against the patient's various bodily fluids until at least 3 days of treatment have elapsed. The incubation period is 1 to 3 days. The diagnostic tests are examination of saliva, blood, CSF, and bubo aspiration to search for Gram+ coccobacilli .

The signs and symptoms are a sudden onset of fever, chills, headache, myalgia, and prostration. The pulmonary form produces coughing, hemoptysis, chest pain, and pneumonia with lung cavity. In the bubonic form, there are cervical, axillary, and inguinal adenopathies. This is followed by septicemia, myocarditis, hypotension, convulsions, disseminated intravascular coagulation, and necrosis of the extremities.

For treatment, in addition to support, the recommendation is streptomycine 15 mg/kg/day IV divided into 2 doses or gentamicine 1-1.75 mg/kg IV q8h, or tetracycline 500 mg IV qid, all for 10 days. Preventive treatment is recommended for asymptomatic contacts: doxycycline 100 mg po bid, or ciprofloxacine 500 mg po bid, or tetracycline 250 mg po qid, all for 7 days. No vaccine is available.

Botulism

The causal agent is the botulism toxin and transmission is by inhalation and ingestion. The illness is not communicable from person to person. The usual infection-control procedures must be applied. The incubation period averages 12 to 72 hours, yet can range from 2 hours to 8 days. The diagnostic tests are a bioassay on mice (5-7 days) and an ELISA to check for the presence of botulism toxin.

The signs and symptoms are: an absence of fever; the pupils are dilated or nonreactive, diplopia, and palpebral ptosis; paralysis of the cranial nerves with dysarthria and dysphonia. Also observed are descending flaccid paralysis without sensory dysfunction, and paralysis of the diaphragm with respiratory arrest. Mental state remains intact.

Treatment includes ventilatory support, parenteral hyperalimentation, and the use of botulinic antitoxin that improves the prognosis if administered early. No preventive treatment is available.

Tularemia

The causal agent, *Francisella tularensis*, comes from the carcasses of dead animals. Transmission is by inhalation. It is not communicable from person

to person. The usual infection-control procedures should be applied. The incubation period is 2 to 5 days, but occasionally reaches 21 days. The diagnostic tests are the presence of Gram-negative bacilli on blood agar-culture and a microagglutination test.

The signs and symptoms are fever, chills, headaches, chest pain of the pleuritic and oppressive type with coughing and rarely hemoptysis, and pneumonia with perihilar adenopathies. Widespread adenopathies and hepatosplenomegaly are also observed. Various diffuse skin rashes may occur as well. Tularemia is quickly fatal.

The treatment is to administer streptomycine 15 mg/kg IM bid or gentamicine 3-5 mg/kg/day IV, or ciprofloxacine 400 mg IV bid, all for 14 days. The recommended preventive treatment is ciprofloxacine 500 mg po bid, or doxycycline 100 mg po bid, or tetracycline 250 mg po qid, all for 14 days. No vaccine is presently available.

Variola or Smallpox

The causal agent is the variola virus. Transmission is by inhalation and from person to person. The usual infection-control procedures apply. The patient and their clothing must be washed. Caregivers must wear masks. The incubation period averages 2 to 17 days. The diagnosis is confirmed by electronic microscope examination of pustular content. Smallpox is highly contagious; 33% of exposed individuals develop the disease.

The signs and symptoms are high fever, myalgia, abdominal pain, and delirium. The skin exhibits pruritis and a rash that is initially maculopapular, then becomes vesicular. These lesions first affect the extremities (head, arms, legs).

The only treatment is support. Vaccinating all potential contacts and caregivers is vital.

CHEMICAL AGENTS

These agents fall into two categories: lethal, which includes neurotoxins, cyanogens, pulmonary agents and vesicants; and non-lethal, which includes tear gas, agents that cause vomiting and mentally disabling chemicals. This discussion will focus on the lethal agents.

The presence of these agents should be suspected with the sudden occurrence of unusual illnesses or the increased density of a syndrome in a geographic area and timeframe. In brief, any sudden rise in the following nonspecific syndromes: sudden unexplained weakness, symptoms of hypersecretion (lacrimation), increased expectoration and diarrhea, irritated eyes and airways, and the presence of skin lesions (erythema, vesicles, pruritis) should be warning signals.

If an attack is suspected, it is important to notify officials, the poison centre, public health officials, and management at your hospital. Apply your establishment's emergency measures plan. With exposure to chemical agents, decontamination is extremely important and must be the first stage of treatment. This means immediately establishing a decontamination zone, undressing and decontaminating patients with soap and water, throwing all their effects into a trash bag and sealing it. Remember, treating patients before decontaminating them in an uncontaminated area will contaminate that area.

Neurotoxic Agents

Neurotoxic agents are odourless, colourless and tasteless; hence, they can be present without being detectable. These agents bind to acetylcholinesterase, increasing stimulation at the synaptic junctions between nerve and nerve, nerve and muscle fibre, and nerve and effector cell. They include derivatives of phosphoric acid. The treatment resembles that for organophosphates (insecticides) intoxication. Absorption is by inhalation and through the skin. The onset of their action is swift: a few seconds for vapors and a few minutes to a few hours for droplets of fluid.

The signs and symptoms include myosis, sore eyes, problems seeing, runny nose, excessive salivation, excessive sweating, increased expectorations, nausea, vomiting, abdominal cramps, diarrhea, tenesmus, urinary and fecal incontinence, asthmatiform crisis, bradycardia,

cyanosis, apnea, muscular weakness and trembling. Severe cases also bring hypotension, fasciculations, convulsions, stupor, and loss of consciousness.

The diagnostic tests are plasmatic cholinesterase dosage and urine screening. Treatment begins by undressing and washing the patient with soap and water. If the patient's condition is serious, a rapid injection of pralidoxime (2-PAM) 1-1.5 gm IV in 20-30 minutes and atropine 2 mg IV is necessary. The main treatment is one of support combined with administration of pralidoxime 1-1.5 gm IV in 20-30 minutes which can be repeated twice at intervals of 60-90 minutes (remember that pralidoxine's T1/2 is 1-1.5 hours), and atropine 2 mg IV q 5-10 minutes until the secretions diminish and ventilation improves. If the symptoms are severe, the case may call for 15-20 mg IV of atropine. Over a 24-hour period, 200 mg IV of atropine may be necessary. Lorazepam or diazepam IV should be used to reduce the convulsions.

Cyanogens

Cyanogens are colourless, but they have an almond scent detectable by 60%-80 % of the population. Absorption is by inhalation and through the skin. These agents cause cellular asphyxia by blocking the oxydase cytochrome. They are fast-acting (within seconds to a few minutes).

The signs and symptoms include dizziness, eye irritation, weakness, difficulty breathing, nausea, headaches, and confusion. The venous blood is bright red and the mucosal membranes are pink. At first, there is a rise in heartrate and blood pressure; this is followed by bradycardia, hypotension, and cardiac arrest. Loss of consciousness, convulsions, and respiratory arrest may also occur. The diagnostic tests include blood and urinary thiocyanate, as well as blood cyanide dosage.

Treatment involves decontaminating the patient, providing support therapy, correcting the acidosis and administering the antidote: amylnitrite by inhalation q 90 seconds through the victim's mask (4-5 ampules maximum), sodium nitrite 300 mg IV in 3 minutes and sodium thiosulfate 12.5 gm IV in 5-10 minutes. If, 30 minutes later, there is no response or the symptoms recur, the sodium nitrite and sodium thiosulfate must be readministered once at half the initial dose. It is important to remember that nitrite converts Hb into MetHb and thiosulfate converts cyanide into thiocyanate. Remember, as well, not to administer methylene blue because it can convert MetHb into Hb and thereby antagonize the action of the nitrites.

Pulmonary Agents

Pulmonary agents smell like freshly cut grass and are only absorbed by inhalation. They are quickly destroyed by water. This class includes phosgene and chlorine. They cause pulmonary edema and the symptoms appear in one to 24 hours.

The signs and symptoms appear in three stages; the first stage is characterized by coughing, watery eyes, sore throat, and headache. This is followed by the latency phase during which the symptoms disappear. Finally, the late phase occurs 2 to 24 hours later; it is characterized by the appearance of cutaneous and mucosal erythema, dyspnea, wheezing, orthopnea, increased expectorations, chest pain, pulmonary edema, hypovolemia, and a state of shock. There is no specific test, but the white cell count and hematocrit are up.

These agents do not require decontamination. The treatment is one of support. Patients improve within 48 hours or die. The long-term complications are asthma and emphysema.

Vesicants

Vesicants are liquid oil dispersed in a fine mist and they smell like garlic, horseradish, or mustard. Typical vesicants are mustard gas and lewisite agents. Absorption is by inhalation and through the skin. Their action begins within 12 to 72 hours, yet, the range extends from 2 minutes to 8 days.

The signs and symptoms affect 4 systems: the skin with erythema, burn-type pain, pruritis and vesicles; the eyes with burning, redness

and lacrimation; the respiratory system with sore throat, productive cough, hoarse voice, dyspnea, pneumonia, and acute edema; and lastly, the digestive system with nausea, vomiting, and diarrhea. There is no specific test. Decontamination consists of undressing and washing the patient with a large amount of water.

The treatment is the same as for chemical burns with the addition of support therapy. Note too, that for lewisite agents, you can use BAL (British antilewisite), an ointment applied to the skin lesions, and dimercaprol 10% by injection IM (3-4 cc) which must be administered as soon as possible, followed by additional injections 4, 8 and 12 hours later. In severe cases, this is followed by regular injections of 2 cc IM dimercaprol for 3 to 4 days.

CONCLUSION

It is important for anesthesiologists to be familiar with the various aspects of medical treatment for all the agents most likely to be used in a terrorist attack. Adherence to, and the application of, basic principles regarding decontamination, treatment, and prevention are vital.

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