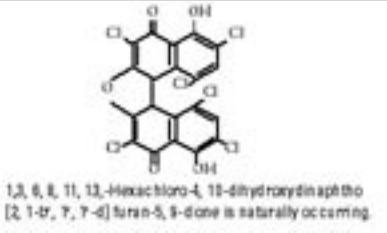
Chemical Terrorism Fact Sheet

Chlorine



Chlorine Chemical Structure.
Photo courtesy of the National Institutes of Health

Protective Equipment/Detection

There are a variety of rubber and plastic materials that resist chlorine, and emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment may be necessary. Rescue vehicles should carry supplies such as chlorine-resistant plastic sheeting and disposable bags to assist in preventing spread of contamination.

Decontamination

Acute exposure may require decontamination and life support for the victims. Victims should first be removed from the area of exposure into an area with fresh air. Remove and double-bag contaminated clothing and personal belongings. With eye exposure, flush the eyes with lukewarm water for a minimum of 15 minutes. Similarly, exposed skin and hair should be flushed with plain water for 5 minutes and then washed with soap and water for at least 15 minutes, rinsing thoroughly afterwards.

Signs and Symptoms

Chlorine gas is highly corrosive when it contacts moist tissues such as the eyes, skin, and upper respiratory tract. As a gas, chlorine's major route of toxicity is inhalation. Significant dermal absorption or ingestion is unlikely because it is a gas at room temperature. However, solutions such as sodium hypochlorite that can generate chlorine can be highly corrosive to the skin or GI tract. Chlorine's strong oxidizing capability, in which chlorine splits hydrogen from water, causes the release of nascent oxygen and hydrogen chloride, which produce major tissue damage. Alternatively, chlorine may be converted to hypochlorous acid, which can penetrate cells and react with cytoplasmic proteins to form N-chloro derivatives that can destroy cell structure. Symptoms may be apparent immediately or delayed for a few hours. Children may be more vulnerable to chlorine gas than adults because of their smaller airway diameters, their increased minute ventilation per kg, their greater lung surface area to body weight ratio, their inability to evacuate an area promptly when exposed, and their short stature, when higher concentrations of the chemical are found at low-lying areas.

Respiratory System: Breathing small amounts of chlorine for even short periods of time has adverse effects on the respiratory system. Exposure to low concentrations (1 to 10 ppm) can cause eye and nasal irritation, sore throat, a stinging chest pain and coughing. Inhalation of higher concentrations (>15 ppm) can rapidly lead to respiratory distress with airway constriction and pulmonary edema. Tachypnea, dyspnea, cyanosis, wheezing, rales, a feeling of suffocation, and/or hemoptysis may rapidly develop. Symptomatic patients complaining of persistent shortness of breath, severe cough, or chest tightness should be admitted to the hospital and observed until symptom-free. Pulmonary injury may progress over several hours, and result in lung collapse. The lowest lethal concentration for a 30-minute exposure has been estimated as 430 ppm, while concentrations of 1000 ppm can be fatal within minutes.

Cardiovascular: Tachycardia and initial hypertension followed by hypotension may occur. After severe exposure, cardiovascular collapse may occur from lack of oxygen.

Chemical Overview

Chlorine is a noncombustible yellow-green, gas with a pungent, irritating odor, is widely distributed in nature although not as a free element. Sodium chloride in seawater and natural deposits of carnallite ($KMgCl_3 \cdot 6H_2O$) and sylvite (KCl) make up roughly 2% of the earth's surface materials. The elemental gas, Cl, is produced by electrolysis of sodium chloride brine. Chlorine is heavier than air and may collect in low-lying areas.

Chlorine is a strong oxidizing agent that can react explosively or form explosive compounds with many common materials. It is only slightly soluble in water, but combines with it to form hypochlorous acid (HClO) and hydrochloric acid (HCl). The unstable HClO readily decomposes, forming oxygen free radicals. Because of these reactions, water greatly enhances chlorine's oxidizing and corrosive effects.

Chlorine's most important use is as a bleach in the manufacture of paper and cloth. It is also used widely as a chemical reagent in the synthesis and manufacture of metallic chlorides, chlorinated solvents, pesticides, polymers, synthetic rubbers, and refrigerants. Sodium hypochlorite, which is a component of commercial bleaches, cleaning solutions, and disinfectants for drinking water, wastewater purification systems, and swimming pools, releases chlorine gas when it comes in contact with acids.

Pure chlorine is generally found only in industrial settings. The typical exposure to chlorine occurs in the workplace or environment following accidental releases of the gas. People who use chlorine-based laundry bleach and swimming pool chemicals are not exposed to chlorine itself.

Signs and Symptoms (Continued)

Metabolic: Insufficient tissue oxygenation can produce acidosis. A major inhalation exposure can produce an unusual form of acid-base imbalance, hyperchloremic metabolic acidosis, caused by an excess of chloride ions in the blood.

Skin: Chlorine's corrosive effects irritate the skin, causing burning pain, inflammation, sweating and blisters. Exposure to liquefied chlorine can produce frostbite injury. Direct contact with liquid chlorine or concentrated vapor can produce a severe chemical burn similar to a thermal burn.

Eyes: Low concentrations in air can cause burning discomfort, spasmodic blinking or involuntary closing of the eyelids, redness, conjunctivitis, and tearing. Corneal burns may occur at high concentrations.

General: Other symptoms may include dizziness, agitation, anxiety, nausea and vomiting.

Treatment

General: There is no specific treatment for chlorine exposure and care is primarily supportive. Patients who are comatose, hypotensive, having seizures or who have cardiac arrhythmias should be treated according to advanced life support (ALS) protocols.

Cardiopulmonary: With severe respiratory compromise, secure the airway and maintain ventilation via endotracheal intubation under direct visualization or by cricothyroidectomy. Avoid blind nasotracheal intubation or the use of an esophageal obturator. Treat bronchospasm with aerosolized bronchodilators. Cardiac sensitizing agents may also be appropriate; and the use of bronchial or cardiac sensitizing agents adds no additional risk after chlorine exposure. Consider aerosolized epinephrine at a dose of 0.25–0.75 ml of 2.25% racemic epinephrine solution in 2.5 cc water, repeated every 20 minutes as needed, for children who develop stridor.

Skin: If chemical burns occur; treat them as you would thermal burns. For frostbite secondary to contact with liquefied chlorine, treat by rewarming affected areas in a water bath at a temperature of 102° to 108° F (40° to 42° C) for 20 to 30 minutes and continue until a flush has returned to the affected area.

Eyes: Irrigate chlorine-exposed eyes for at least 15 minutes. Test visual acuity, check for corneal damage, and treat appropriately. Corneal injuries require urgent consultation by an ophthalmologist.

Laboratory Tests: The diagnosis of acute chlorine toxicity is a clinical one. Lab testing is useful for monitoring the patient and evaluating complications. Routine studies include CBC, glucose, and electrolytes. Patients with respiratory symptoms should have pulse oximetry (or ABG measurements) and a chest x-ray. If hyperchloremic metabolic acidosis is present, monitor the blood pH closely.

Additional information and references available at http.www.bioterrorism.slu.edu

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Long-term Medical Sequelae

Pulmonary function usually normalizes within 7 to 14 days after acute exposure, and complete recovery generally occurs. However, flu-like symptoms and prolonged pulmonary impairment may persist as a result of reactive airways dysfunction syndrome (RADS), a chemical irritant-induced type of asthma.

The health effects associated with breathing small amounts of chlorine over long periods of time are not known, but are currently under investigation. Some studies show that workers develop adverse effects from repeated inhalation exposures, but others do not. Chronic exposure has been shown to cause corrosion of the teeth. Chlorine has not been classified for carcinogenic effects, but the association of cigarette smoking and chlorine fumes may increase the risk of cancer. No information is available regarding reproductive or developmental effects of chlorine in experimental animals or humans.

Environmental Sequelae

Chlorine causes environmental harm at low levels, being especially harmful to organisms living in water and in soil. Most direct releases of chlorine to the environment are to air and to surface water. Once released, chlorine reacts with other chemicals. In water, it combines with inorganic material to form chloride salts and with organic material to form chlorinated organic chemicals. Because of its reactivity, chlorine is not likely to move through the ground and enter groundwater.

Disclaimer

Information contained in this fact sheet was current as of September 2002, and was designed for educational purposes only. Medication information should always be researched and verified before initiation of patient treatment.

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