Factsheet

Pulmonary (Choking) Agents

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Background

Pulmonary agents (also known as "choking" agents) are chemicals that can cause severe irritation or swelling of the respiratory tract, disrupt breathing, and potentially cause permanent lung damage. They encompass a wide array of gases, including chlorine, ammonia, phosgene, organohalides, and nitrogen oxides. Many of these compounds are used for industrial and manufacturing purposes.[1,2,3] These compounds have figured prominently in military conflicts; notably, World War I, the Iraq War, and the Syrian Civil War.[4] WWI alone saw nearly 100,000 cases of gas poisoning among US troops.[5] Unlike other chemical weapons, however, the chemicals that function as choking agents play important roles in the civilian and commercial sectors. Many toxic industrial chemicals, precursors, and biproducts can double as choking agents, but they typically are used for processes such as cleaning and producing plastics, pesticides, and fabrics, among many other uses.[2,6]

Use as Chemical Warfare Agents

Chlorine: As early as the US Civil War, advocates for chemical weapons proposed artillery shells be filled with chlorine to deploy during battle to weaken the defenses of their adversary, but none of these ideas were implemented during battle.[7] Chemical weapons played a significant role during WWI, with German forces first employing chlorine gas against their adversaries during the Second Battle of Ypres in 1915.[3,4] Chlorine-based weaponry has also figured into more recent conflicts, despite the Geneva Protocol by the League of Nations prohibiting their use. Insurgents used chlorine gas against their enemies in the Iraq War, and Syria has been the subject of investigation by the Organisation for the Prohibition of Chemical Weapons (OPCW), which confirmed use of chlorine gas by the Syrian government during the Syrian Civil War as recently as 2018.[4]

Phosgene: British physician and chemist John Davy first synthesized phosgene in 1812; it has since become an important component of dye and pesticide production.[8] During WWI, phosgene emerged as a sophisticated alternative to chlorine gas. Chlorine gas often caused victims to cough and choke violently; phosgene, by contrast, caused much less coughing, resulting in increased gas inhalation. Military forces even formulated a "white star" concoction consisting of a phosgene-chlorine mix, and the chlorine vapor in this mix effectively spread the phosgene over a wider geographic area.[7] More recently, during the North Yemen Civil War of 1962-1970, Egyptian soldiers employed phosgene-loaded bombs and artillery shells against both Yemeni civilians and Royalist troops.[9]

Chloropicrin: John Stenhouse, a Scottish chemist, first synthesized chloropicrin in 1848. While it is not as lethal as other choking agents, chloropicrin, which is also known as a riot control agent, induces severe vomiting and excessive tear formation in its victims.[10] Chloropicrin was used in large quantities in WWI, as more and more troops were sent into battle equipped with gas masks. Chloropicrin could bypass gas masks and cause sneezing fits, causing soldiers to remove their masks, leaving them exposed to other dangerous and poisonous gases that could be mixed with the chloropicrin.[11,12]

Mechanism of Action & Physical Properties

Choking agents function in liquid, gaseous, or aerosolized forms. In their gaseous form, they operate primarily by irritating the respiratory tract—including the mucous membranes, nasal passage, throat, airways, and lungs—and inducing swelling in these areas.

Chlorine is a dense, yellowish gas at room temperature and is relatively insoluble in water. Upon inhalation, water inside the body oxidizes chlorine gas to produce hydrochloric acid (HCL) and hypochlorous acid (HClO). HClO penetrates cells and reacts with proteins to degrade cellular structures. Severity of injury is proportional to the duration of the exposure and the concentration of the gas at the time of exposure.[6]

Phosgene gas, meanwhile, is colorless and is said to smell like freshly mown hay. Liquid phosgene is extremely volatile and reacts violently with water and ammonia—decomposing rapidly in both to produce hydrochloric acid and urea, respectively. This reaction causes an onset of irritation and symptoms in the mucous membranes where it was absorbed. Like chlorine, the concentration of gas and length of exposure determine severity of injury. Phosgene evaporates quickly from the skin, allowing for effective decontamination with water.[6]

Chloropicrin, like phosgene, is also a colorless gas or can appear as a light green-to-brown oily liquid. It is highly volatile and features a sharp, intensely irritating odor. A powerful oxidant, it reacts readily with aluminum, magnesium, and their associated alloys to produce a toxic, corrosive gas.[13]

Signs & Symptoms

Choking agents enter the body primarily via inhalation, and their effects vary by type and level of exposure. In the short term, low exposure to any of the choking agents typically damages the larger airways. In fact, exposure to as little as 15 parts per million (PPM) of chlorine gas can trigger respiratory irritation, coughing, and chest constriction. In addition to thoracic and respiratory distress, the immediate effects of choking agent exposure also include burning of the eyes, nose, and throat. Chlorine and phosgene gas may also cause blistering and skin lesions, blurred vision, excessive tear formation, nausea, low blood pressure, and heart failure. Chloropicrin exposure causes skin irritation, chemical burns, and vomiting, and it inflicts severe damage upon the respiratory lining.

The long-term results of choking agent exposure include permanent damage to the lung tissues and heart failure. Although choking agents are intended to be debilitative rather than lethal, very high doses of chlorine, phosgene, or chloropicrin can cause rapid death. Exposure to 1000 PPM of chlorine, for example, is fatal after only a few deep breaths.[4,6]

Short- and Long-Term Effects of Choking Agent Exposure

	Thoracic/Respiratory	Dermatalogical	Cardiovascular	Ophthalmological
Short-Term Effects	• Chest tightness • Coughing • Wheezing • Asphyxiation	• Dermatitis • Discoloration • Blisters • Burning sensation • Chemical burns	• Slow heart rate • Low blood pressure	• Blurred vision • Burning sensation • Excessive tear formation
Long-Term Effects	• Respiratory failure • Chronic bronchitis • Emphysema	• Cyanosis	• Irregular pulse • Congestive heart failure	• Blindness • Glaucoma

Diagnosis

Immediate diagnosis of lung poisoning is difficult, given the relative nonspecificity of the symptoms associated with choking agent exposure. Furthermore, there is no clinical test for detecting chlorine, chloropicrin, or phosgene in the respiratory system. Diagnosticians must rely instead on patient histories to determine potential routes of exposure. Differential diagnosis of choking agent poisoning depends on the presence of mucosal irritation and deep lung effects in addition to the aforementioned symptoms.[4]

Treatment

There is no antidote against any of the choking agents. The North Atlantic Treaty Organization (NATO) has undertaken research to devise new therapies for agents of chemical terrorism, but these endeavors have realized only limited success. Therefore, medical treatment for those exposed to chlorine, phosgene, or chloropicrin is largely supportive and decontaminative in nature. Specific strategies include secretion management, oxygen therapy, and administration of high-dose steroids to reduce respiratory swelling. Intubation and mechanical ventilation maybe required. Caregivers should exercise caution in using sedatives on patients whose airways and breathing are not controlled.[4,6]

Decontamination

Decontamination is a critical step in mitigating the effects of choking agents. Those who come into physical contact with chlorine, phosgene, or chloropicrin should immediately remove their clothing, making sure to cut contaminated garments off rather than pull them over their faces. Garments should then be sealed in plastic bags for inspection and removal by health authorities. Exposed individuals should also rinse their skin with soap and water, remove their jewelry, and dispose of their contact lenses before seeking medical attention.[2,4,6]

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