PULMONARY INTOXICANTS

Pulmonary intoxicants cause severe life-threatening lung injury after inhalation. These effects are generally delayed several hours after exposure. Treatment is usually supportive and may require advanced intensive care techniques including intubation, use of a mechanical ventilation and PEEP. Pulmonary intoxicants included with this group are phosgene and chlorine.

Phosgene
Phosgene is widely used today in the manufacturing of dyes, coal tar, pesticides, and pharmaceuticals. It was widely used in WWI until mustard was introduced on the battlefield.

The Bhopal, India disaster of 1984, at a Union Carbide plant, involved the release of 50,000 pounds of methylisocyanate. This chemical is composed of phosgene and methylamine. There were 150,000 people affected, 10,000 severely injured, and 3,300 killed. The effects of the release were thought to be due to a combination of isocyanate and phosgene.

Characteristics
Phosgene has a characteristic odor of freshly mown hay and is four times heavier than air. It is a gas above 47 ºF, and is principally a hazard by inhalation.

Mechanism of Action and Clinical Effects
Phosgene dissolves slowly in water to form carbon dioxide and hydrochloric acid (HCl). In contact with the moist mucosa the HCl causes a transient irritation of the eyes, nose, sinuses, and throat. It can also irritate the upper airway and bronchi, causing a dry cough. However, the primary damage from phosgene is from the carbonyl group, which destroys the alveolar capillary membrane. (Perfluoroisobutylene, PFIB, the combustion product of burning Teflon, found in many military vehicles, has a similar action as phosgene, but is more toxic.)

Phosgene penetrates poorly into the airways due to its poor water solubility. There is a symptom-free period of 2 to 24 hours. Over the first several hours, the carbonyl group from the phosgene attacks the surface of the alveolar capillaries. Eventually, this causes the leakage of serum from the capillaries in the lung into the alveoli and interstitial space. The fluid fills the tissues, causing severe hypoxia and apnea. As the fluid leaks into the alveoli, massive amounts of fluid (up to 1 liter per hour) pour out of the circulation. The patient develops a severe non-cardiogenic pulmonary edema.

Medical Management and Treatment
The leakage of fluid in the lungs causes volume depletion. Although the patient may clinically look like traditional heart failure, DO NOT USE DIURETICS. These patients are volume depleted. Treat hypotension with fluids. These patients may require intubation and the use of PEEP.

In the hospital, the initial examination of a patient, symptomatic or not, should include – (as a minimum): auscultation, chest x-ray, and arterial blood gases. If the victim develops severe dyspnea due to upper airway irritation, early intubation should be considered to manage oxygen delivery and to prevent laryngeal spasm. The airway should be suctioned frequently to remove secretions. According to some authorities, antibiotic use should be guided by Gram stain and culture results. Another source recommends prophylactic antibiotics, as autopsy studies show uniform evidence of pneumonia and bronchitis.

Ventilator management, PEEP, and oxygen administration might require consultation with a pulmonologist. Fluid hydration may be necessary to treat the hypotension, bradycardia, or impending renal failure. Diuretics such as Lasix are contraindicated because of the hypotension and the noncardiac nature of the pulmonary edema. Standard bronchodilators will usually control bronchospasm, but if not, steroids may be needed for this purpose. Routine steroid use is
controversial, but steroids seemed to offer some efficacy after the Bhopal tragedy. Once the patient recovers, there should be little residual pulmonary effect.

**Chlorine**
Chlorine is a significant irritant to the eyes and respiratory tract. It is widely used in the manufacture of chemicals, plastics, and paper and is commonly used in swimming pools and laboratories. Industrial exposures have produced large numbers of injuries.

**Characteristics**
Chlorine is a greenish yellow gas that has a characteristic pungent odor that is irritating to the nasal mucosa. It is transported as a liquid and is less alkaline than ammonia.

**Mechanism of Action and Clinical Effects**
Chlorine injures cells by reacting with water, producing hydrochloric acid (irritating) and free oxygen radicals (attack cells). It is toxic to any body surface including the eyes, skin, respiratory tract, and GI tract. Chlorine gas is 30 times more irritating to the respiratory mucosa than HCl.

In seconds after the exposure, there are symptoms of irritation to the eyes, nose, and throat. This is followed by irritation of the respiratory tract with coughing, shortness of breath, wheezing, chest pain, and sputum production. Initial respiratory distress is followed in 12 to 24 hours by noncardiogenic pulmonary edema. Sudden death is usually due to severe hypoxia and cardiac arrest.

**Medical Management and Treatment**
Move exposed victims away from the source of exposure. If the victim has no complaints, probably no treatment will be necessary.

Toxicity to skin and eyes should be treated with copious flushing with water. Irritation of the respiratory tract is treated with oxygen, cool mist to moisten the damaged mucosa, and bronchodilators to resolve bronchospasm.

Intubation, mechanical ventilation, and assessment of hydration may be required. Bronchoscopy may be useful to remove mucosal plugs.

**Ammonia**

**Characteristics**
Ammonia is a colorless, highly water-soluble, alkaline gas that has a pungent odor. It is widely used industrially in the U.S. with over 500,000 workers potentially exposed annually. It is used as an agricultural fertilizer and is used in the manufacture of explosives, dyes, and plastics.

**Mechanism of Action**
Ammonia is rapidly absorbed by mucosal surfaces and causes damage to the eyes, oral cavity, throat, and lungs. When mixed with water, it forms a corrosive agent, ammonium hydroxide (NH₄OH) that causes considerable damage in the form of liquefaction necrosis. Due to its high water solubility, ammonia penetrates rapidly into tissue. Household ammonia generally has a pH less than 12 and generally causes limited damage to eyes or mucosa. Anhydrous ammonia is an industrial chemical that has a very high pH and is extremely corrosive and can cause severe damage to the eyes, lungs, and skin.

**Clinical Effects**

**Ophthalmic**
Initially, ammonia causes burning, tearing, and severe pain. It has a tremendous capacity to penetrate the eye, causing corneal opacification and lens damage leading to cataract formation.
**Pulmonary**
Mild exposure causes cough, shortness of breath, chest pain, wheezing, and laryngitis. Higher exposure can cause hypoxia, chemical pneumonia (pneumonitis), and hemorrhage. This will gradually improve over 72 hours. If the patient survives the first 24 hours, recovery is probable.

**Integumentary**
Pain, blister formation, and possibly deep burns similar to frostbite can occur.

**Gastrointestinal**
If ammonia is ingested, severe mouth pain, cough, abdominal pain, nausea, and vomiting can occur. Severe edema of lips and mouth is seen. The patient should be examined to make certain that laryngeal irritation does not cause airway obstruction. Esophageal stricture and perforation is common.

**Medical Management**
After the patient has been removed from the area of exposure, decontamination should be started immediately in the field.

**General Management**
Remove all clothing and wash skin and hair with soap and large amounts of water for 15 to 20 minutes.

Cover burns with a sterile dressing.

The eyes should be irrigated continuously with water. A Morgan lens device and topical analgesics will enable continuous eye irrigation therapy. Both of these items should be considered part of an antidote/equipment cache. Slit lamp exam after fluorescein staining will reveal the ocular injury.

Damage to the lungs is common after inhaling anhydrous ammonia, often resulting in Non-cardiogenic pulmonary edema. Since the victims may quickly develop shortness of breath and laryngeal swelling, early intubation should be considered to protect the airway.