

# CHLORINE

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## Description

Chlorine is a greenish yellow gas at room temperature and pressure with a pungent, irritating odour. It is slightly water soluble, heavier than air and tends to accumulate at ground level. Usually transported as a pressurized liquid; when released, one liter of liquid chlorine produces 434 liters of chlorine gas at 25 degrees C. Chlorine is used in synthesis of chlorinated organic chemicals and plastics, water purification, paper bleaching, metal fluxing and degreasing agents. *Chlorine* gas is produced when household bleach containing hypochlorites is mixed with strong acids. *Chloramine* gas is produced when household bleach is mixed with ammonia. Chloramine is more water soluble than chlorine, but less than ammonia.

## Toxicity

Primary toxicity is mucous membrane irritation and caustic injury. Exposure to concentrations produced by household cleaning agents commonly results in mild irritation (throat irritation, cough, dyspnea) that resolves within 6 hours of exposure. Exposure to more concentrated chlorine gas as may occur following a train derailment or an industrial leak can result in significant pulmonary injury including pulmonary edema and respiratory failure.

Onset of symptoms can be immediate or delayed; acute lung injury peaks in about 12-24 hours. Symptoms following mild exposures usually resolve within 6 hours, but may continue for 24 hours or more in severe exposures.

## Mechanism of Toxicity

*Chlorine* is a potent oxidizing agent which generates oxygen free radicals and forms hydrochloric and hypochlorous acids on contact with moist mucous membranes. Toxicity results from corrosive effect of acids on skin and mucous membranes, and from cellular necrosis mediated by free radical disruption of cellular proteins. Because it is not highly water soluble, initial symptoms may be mild but may worsen over several hours.

*Chloramine* produces similar toxicity as chlorine. Onset of symptoms may be more rapid due to increased water solubility.

## Toxic Dose

Toxicity varies with concentration and duration of exposure. Short exposures to concentrations of 1-3 ppm produce mild mucous membrane irritation. Exposures to > 40 ppm can lead to pneumonitis and pulmonary edema; an exposure to 430 ppm for 30 minutes can be lethal. Concentration liberated from mixing of household cleaners is generally < 1 ppm.

## Case Reports

A 12-year-old retrieved a bucket containing 30 chlorine tablets from a swimming pool and developed lethargy, dry cough and tachypnea. Chest x-ray showed pulmonary edema. Over the next 3 hours patient became increasingly tachypneic, cyanotic and unresponsive. ABGs revealed pH 7.25, pCO<sub>2</sub> 54 mmHg, pO<sub>2</sub> 43 mmHg. Patient required mechanical ventilation with PEEP for 36 hours and recovered without sequelae.

Eighty-two patients were exposed to 66 ppm chlorine gas

and developed cough and dyspnea. Other symptoms included irritation of throat (54% of patients), headache (29%), abdominal pain (27%) and vomiting (24%). Fifty-six patients had bronchoscopy which revealed tracheobronchial mucosal congestion in all cases and hemorrhagic spots in 20 patients. Two patients developed pulmonary edema at 12 hours post exposure. All patients received oxygen, aminophylline, hydrocortisone and antibiotics, and all recovered.

## Clinical Effects

- **Topical:** Irritation and erythema. Potential burns with high concentrations. Frostbite may result from contact with escaped compressed gas. Green discoloration of hair may be seen in patients with blonde or grey hair following regular swimming in chlorinated water.

- **Ocular:** Stinging, burning sensation, tearing and conjunctivitis may occur after exposure to low concentrations. Symptoms may decrease with continued exposure due to decreased sensitivity. Severe burns with high concentrations.

- **Inhalation:**

- **General:** Symptoms can be immediate or delayed. Coughing, burning sensation in chest, hoarseness and shortness of breath commonly are seen with exposure to low concentrations. Rhonchi, bronchospasm, tachypnea, rales and cyanosis can be seen with more severe exposures. Symptoms usually resolve within 6 hours after mild exposures but may continue for 24 hours or more in severe exposures.

- **HEENT:** Irritation of eyes, nose. Laryngospasm.

- **CVS:** Tachycardia, ventricular dysrhythmias (rare) have occurred. Cardiovascular collapse has been reported with severe toxicity (rare).

- **Respiratory:** Coughing, burning sensation in chest, hoarseness and shortness of breath (common with exposure to low concentrations). Rhonchi, bronchospasm, tachypnea, rales and hypoxia can be seen with more severe exposures. Pneumonitis, pulmonary edema and respiratory failure may occur. Persistent reactive airway disease (RADs) has occasionally been reported after exposure to chlorine in patients with pre-existing lung disease. Increased airway reactivity has been reported after a single

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exposure, and may persist for years in some cases (uncommon).

**Neurologic:** Headache. Anxiety and agitation may occur with more severe exposures. Lethargy and coma may accompany respiratory compromise.

**GI:** Nausea and vomiting may occur with mild exposures.

**Fluids/Lytes/Acid-Base:** Metabolic acidosis has been reported (uncommon).

### Treatment

1. **Topical:** Wash skin thoroughly with copious amounts of water.
2. **Ocular:** Flush eyes with a gentle stream of tepid water for 15 minutes. Obtain ophthalmologic opinion if irritation persists.
3. **Inhalation:** Remove from exposure.
4. For *mild* exposures, patient may be managed with steam inhalations or humidified oxygen alone. Sucking on ice chips, throat lozenges or hard candy may relieve throat irritation.
5. For *severe* exposures, monitor vital signs, oxygen saturation, chest X-ray, blood gases. Observe patient for at least 6 hours after severe exposure. Patients with moderate or severe symptoms, with abnormal oxygenation or ventilation, and those with positive chest X-ray should be admitted for longer observation and supportive care.
6. Protect airway and assist ventilation as needed. Administer humidified oxygen and bronchodilators as required.
7. Nebulized sodium bicarbonate may be useful (limited data).
8. Symptomatic and supportive care.