



Cyanide

Fact Sheet

Background

Cyanide is a naturally occurring chemical, found in many plants, that has been used in conventional warfare and poisoning for 2 millennia. It is highly lethal, whether inhaled as a gas, ingested in solid form, or absorbed through topical exposure. Two notorious incidents in recent history—the Jonestown Massacre in 1978 and the Tylenol poisonings in 1982—highlight the lethality of this poison.

First isolated in 1782, cyanide is a compound composed of carbon triple bonded to nitrogen (CN). Cyanide can be released from natural sources, including some foods, and it is contained in several industrial chemicals and in cigarette smoke. It is also used in manufacturing and in pesticides. In medicine, cyanide can be found in the widely used anti-hypertensive, sodium nitroprusside, each molecule of which contains 5 molecules of cyanide. The most common cause of cyanide poisoning is smoke inhalation in fires.

Use as Chemical Warfare Agent

The use of cyanide in warfare dates to the Franco-Prussian War (1870–1871), during which Napoleon III urged his troops to dip their bayonet tips in the poison. Roman Emperor Nero (37–68) also used cyanide-containing cherry laurel water as a poison.

Both World Wars saw the use of cyanide: during World War I, it was employed by French and Austrian troops; and Nazi Germany used the rodenticidal product Zyklon B to kill millions during World War II. In the 1980s, cyanide may have been used in the Iran-Iraq War, on the Kurds in Iraq, and in Syria.

In 1995, the Japanese cult Aum Shinrikyo placed cyanide in subway bathrooms.

This poisonous compound poses an ongoing threat as a weapon of terrorism, whether it is delivered in oral form via sodium cyanide and potassium cyanide or as a gas via hydrogen cyanide and cyanogen chloride.

Mechanism of Action and Toxicokinetics

Cyanide poisons the mitochondrial electron transport chain within cells and renders the body unable to derive energy (adenosine triphosphate—ATP) from oxygen. Specifically, it binds to the a_3 portion (complex IV) of cytochrome oxidase and prevents cells from using oxygen, causing rapid death.

Airborne release of cyanide gas, in the form of hydrogen cyanide or cyanogen chloride, would be expected to be lethal to 50% of those exposed (LC₅₀) at levels of 2,500–5,000 mg•min/m³ and 11,000 mg•min/m³, respectively. When ingested as sodium or potassium cyanide, the lethal dose is 100–200 mg.

Signs and Symptoms

Cyanide kills quickly: death occurs within seconds of a lethal dose of cyanide gas and within minutes of ingestion of a lethal dose of cyanide salt. The central nervous system (CNS) and cardiovascular systems are chiefly affected. Signs and symptoms of cyanide poisoning include the following:

- **CNS:** headache, anxiety, agitation, confusion, lethargy, seizures, and coma;
- **Cardiovascular:** decreased inotropy, bradycardia followed by reflex tachycardia, hypotension, and pulmonary edema; and
- **Other:** acute lung injury, nausea and vomiting, cherry-red skin color.

Survivors may suffer Parkinson's disease, ataxia, optic atrophy, and other neurologic disorders.

Diagnosis

Cyanide intoxication is largely a clinical diagnosis; however, several laboratory features are suggestive:

- Metabolic acidosis (increased anion gap),
- Elevated lactic acid, and
- Venous oxygen saturation > 90%.

Cyanide blood levels are confirmatory, as results are not obtainable in time for initial diagnosis. There are some reports of use of rapid calorimetric paper test strips to confirm the presence of cyanide.

Countermeasures

Before cyanide antidote can be administered, the patient must be removed from the cyanide-laden area, clothing removed, and skin washed with soap and water. If cyanide salts have been ingested, activated charcoal may prevent absorption from the gastrointestinal tract.

Management of cyanide toxicity is based on the principle of reversing and/or displacing cyanide binding to cytochrome a3. There are 2 major modalities of treatment: the cyanide antidote kit and hydroxocobalamin.

- **Cyanide Antidote Kit:** This 3-component process comprising amyl nitrite, sodium nitrate, and sodium thiosulfate releases cyanide from cytochrome a3 by providing a target for which cyanide has a higher attraction. Amyl nitrite, contained in pearls that must be broken and inhaled, and IV sodium nitrate cause the formation of methemoglobin, for which cyanide has a high binding affinity. Sodium thiosulfate provides a source of sulfur that the enzyme rhodanese—the major pathway for metabolism of cyanide—utilizes to detoxify cyanide.

- **Hydroxocobalamin (Cyanokit):** In addition to methemoglobin, cyanide also has a strong binding affinity to cobalt. Hydroxocobalamin, which contains cobalt, becomes cyanocobalamin (vitamin B12) after binding to cyanide. It is then excreted in the urine.

Recovery

Although recovery from a chemical attack is rare, victims may survive sub-lethal exposures, whether from ingestion, smoke inhalation, or exposure to cyanide-containing industrial products, such as carpet. Patients who are treated successfully for cyanide poisoning should be observed for development of long-term neuropsychiatric symptoms that are similar to symptoms experienced by survivors of cardiac arrest or carbon monoxide poisoning.

References

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Holstege CP, Isom GE, Kirk MA. Cyanide poisoning. *Goldfrank's Toxicologic Emergencies, 8th Edition*. McGraw-Hill; 2006.