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Chemical Emergency Medical Guideline

Information and recommendations for healthcare professionals

Cyanides / Hydrocyanic acid

CAS No: 74-90-8

GHS symbols:

GHS06
Acute toxicity

GHS08
Health hazard

Signal word: Danger

Hazard statements:

H300+H310+H330 Danger to life if swallowed, in contact with skin or if inhaled.

Overview

- Before paramedics/emergency doctors on site approach a patient, who has been or is exposed to cyanides, they must ensure that there is no danger to themselves from cyanides.
- There is no danger from contact with patients who have only been exposed to cyanide vapors. However, a patient who is wet with liquids containing cyanide, or whose clothing is contaminated with liquids, may endanger other people through direct contact or through cyanide gas emissions.
- Cyanide poisoning can be fatal within minutes. If cyanide exposure is suspected and there are clinical signs of severe hypoxia, cyanide poisoning should be assumed even if there is no cyanosis.
- If there is reasonable suspicion of cyanide poisoning, immediate administration of pure oxygen is crucial. If the patient shows signs of poisoning, the recommended antidotes (especially 4-DMAP) should be administered.

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1. Information on the substance

Cyanides (CN)
Cyanides are salts of hydrogen cyanide, also known as prussic acid (e.g. potassium cyanide = KCN). Their physical and chemical properties depend on the specific compound. The smell of cyanide compounds does not provide sufficient warning of their dangerous effects.
Alkaline cyanides are used in gold and silver ore extraction, metal surface treatment, electroplating, the manufacture of dyes and pigments, and as pesticides.

2. Exposition

2.1. Inhalation

All respirable cyanide compounds are rapidly absorbed through the lungs.

2.2. Skin/eye contact

Cyanides are very easily absorbed through the skin and mucous membranes; symptoms may be delayed. Eye and skin irritation may occur.

2.3. Ingestion

Most cyanide compounds are absorbed immediately in the gastrointestinal tract. Alkali salts are generally only toxic after ingestion.

3. Acute health effects

The cyanide ion binds to the trivalent iron of mitochondrial cytochrome C oxidase, thereby inhibiting oxidative phosphorylation and ATP production. The cellular oxygen deficiency and inhibition of cellular oxidation processes result in increased anaerobic glycolysis, which then leads to lactic acidosis.
Initial symptoms may include flushing, rapid pulse, shortness of breath, headache and dizziness. Ultimately, this can lead to metabolic acidosis, central nervous system excitation, impaired consciousness or even coma, respiratory paralysis, seizures, bradycardia, drop in blood pressure and death.
A burning sensation in the mouth and throat and reddened eyes have been described.

3.1. Central nervous system

Central nervous system disorders and symptoms generally develop very quickly. Initially, there are often non-specific symptoms, e.g. agitation, dizziness, nausea, vomiting and headaches. Eventually, this can lead to impaired consciousness, respiratory paralysis, seizures and coma.

3.2. Cardiovascular system

Severe poisoning can cause cardiac arrhythmia. Bradycardia, low blood pressure that is barely measurable, and cardiovascular arrest can result from cyanide exposure. Elevated blood pressure and heart rate may occur temporarily immediately after exposure.

3.3. Respiratory tract

Shortness of breath and tightness in the chest may occur even at the onset of systemic poisoning. The respiratory rate has increased, and breathing is deeper. As the poisoning progresses, breathing may become slow and difficult. Cyanosis may occur, but is not necessarily present, as cyanides blocks oxygen utilization in the respiratory chain and not oxygen transport by the erythrocytes. Pulmonary edema may develop.

3.4. Skin contact

Skin contact with liquid cyanides can cause irritation. As cyanides can be easily absorbed through the skin, systemic toxic effects are possible.

3.5. Eye contact

After eye contact with liquids containing cyanides, irritation and oedema may occur. Systemic effects have also been described in animal experiments following eye contact with cyanide salts.

3.6. Acid-base status

In severe cases of poisoning, elevated lactic acid levels in the blood can lead to an anion gap and thus to metabolic acidosis.

3.7. Possible consequences

Survivors of life-threatening exposure should be monitored for possible cerebral or cardiac damage. These patients have an increased risk of central nervous system disorders, including memory deficits or Parkinson's syndrome; clinical follow-up examinations should continue for several weeks to months after exposure.

4. Measures

4.1 Self-protection of first aiders

If there is suspicion that the area the helper must enter contains cyanide, a self-contained breathing apparatus and a chemical protection suit must be worn. Contaminated equipment must not be used.
There is no danger from contact with patients who have only been exposed to cyanide vapors. A patient who is wet with liquids containing cyanide, or whose clothing is wet with such liquids, may endanger other people through direct contact or through evaporating cyanide.

4.2. Rescue

Patients should be removed from the danger zone immediately. If they are unable to walk unaided, they should be removed from the danger zone quickly using appropriate means, taking care to protect themselves. The "A, B, C procedure" has absolute priority.

A) Clear the airways (check for blockages caused by the tongue or foreign objects)
B) Ventilation (check the patient's breathing, if necessary, begin ventilation with adequate self-protection, e.g. breathing mask)
C) Circulation (begin resuscitation on any person who does not respond to verbal commands and is not breathing normally)

"CRASH" decontamination

- Rescue cyanide-contaminated, unconscious or immobile patients (critically ill/injured patients according to the ABCDE scheme) from the immediate danger zone, taking personal precautions and using suitable personal protective equipment
- If necessary, perform emergency measures ("basic life support"; e.g. bleeding control using a tourniquet, chest compressions, etc.)
- At a suitable location outside the danger zone, completely undress the contaminated patient using an emergency rescue knife, taking care to protect yourself (duration: approx. 1 minute).
- Shower/rinse with plenty of water (duration: approx. 1 minute)
- Transfer to a clean stretcher. Ensure body heat is maintained. Transport/handover to the emergency services/emergency doctor (duration: approx. 1 minute)

4.3. Cleaning

Patients suspected of having been in contact with solutions containing cyanide require special cleaning measures that differ from those used for all other patients.
If possible, patients should assist with their own cleaning. If liquid cyanide has been exposed and clothing is contaminated, it must be removed and securely wrapped.

Ensure that the affected skin and hair areas are rinsed with water for at least 15 minutes. Other important first aid measures must be continued during this time. Protect the eyes during rinsing.
In the event of cyanide exposure, ensure that the eyes are rinsed with water or neutral saline solution for at least 15 minutes. Remove any contact lenses, if possible, without causing further injury to the eyes. Continue other important first aid measures during this time.

Do not induce vomiting under any circumstances after ingestion.

Gastric lavage fluid and vomit must be isolated as they may release cyanide. In case of respiratory insufficiency, perform endotracheal intubation or alternative airway management. If this is not feasible, perform coniotomy if necessary.

4.4. Initial treatment (preclinical or clinical)

Speed is crucial. If the patient shows signs of poisoning, 100% oxygen must be administered immediately. The recommended antidotes must then be administered as quickly as possible (see below).

Only if a significant dose has been ingested less than 30 minutes ago should immediate gastric lavage be considered.

Patients who are conscious and able to swallow should receive 50 g of activated charcoal (or 1 g/kg body weight for children weighing up to 50 kg) within two hours of exposure. Repeated administration of activated charcoal is possible at any time to complete decontamination if there are signs or suspicion of ongoing absorption.
For multiple doses, start with the single-dose amount mentioned above, followed by the same dose every four hours or half the dose every two hours. Avoid inhaling the product.

Gastric lavage fluid and vomit must be isolated as they may release cyanide. In case of respiratory insufficiency, perform endotracheal intubation or alternative airway management. If this is not feasible, perform coniotomy if necessary.

4.5 Antidote treatment

Critical or unconscious patients with known or highly probable cyanide poisoning should be treated with antidotes by emergency medical services. If symptoms are present, intravenous treatment should be started immediately, e.g. after relevant skin contamination.
The availability of antidotes may vary from country to country due to legal provisions or regulations. The attending emergency doctor should be informed whether and, if so, which antidotes have already been administered.

Antidote treatment is usually divided into two steps:

Methemoglobin formation (4-dimethylaminophenol = 4-DMAP or amyl and/or sodium nitrite) for rapid elimination of cyanide from the affected enzymes in the respiratory chain, followed by an active substance to form less harmful compounds with cyanide and their excretion (sodium thiosulphate).

Use of 4-dimethylaminophenol = 4-DMAP or amyl and/or sodium nitrite only in cases of high suspicion of cyanide poisoning. These antidotes must not be used under any circumstances in cases of smoke inhalation poisoning with simultaneous release of cyanides, as methemoglobin formation would further reduce oxygen transport capacity in addition to carboxyhemoglobinemia.

An alternative antidote is hydroxocobalamin (=vitamin B12). The intravenous dose for an adult is 5g in 100ml saline solution (hydroxycobalamine 70mg/kg body weight). A second and third dose, but not more than 15g in total, may be considered, especially in cases of persistent cardiovascular failure. However, in cases of severe cyanide poisoning, the binding capacity of a standard dose of hydroxycobalamine is insufficient. In such cases, the use of 4-DMAP is preferable.

Step 1:
Note: In some countries, 0.2-0.4ml amyl nitrite inhalation ampoules (pearls) are available, the use of which is recommended until intravenous treatment can be started. The patient should lie down during

administration, as nitrite lowers blood pressure. The contents of the amyl nitrite bead should be placed in a cloth and held close to the patient's nose for 15-30 seconds. Oxygen should then be administered for 15-30 seconds. The administration of amyl nitrite and oxygen is repeated alternately. A new bead should be used every three minutes.

If 4-dimethylaminophenol (4-DMAP) is available, inject 4-DMAP intravenously immediately. Normally, a dose of 1 ampoule containing 250mg of 4-DMAP is sufficient in adults to achieve a therapeutic methemoglobin level (target methemoglobin level approx. 30-40%).

If 4-DMAP is not available, sodium nitrite should be infused intravenously immediately. The patient should be lying down during administration, as nitrite lowers blood pressure. The usual adult dose is 300mg (10ml of a 3% solution) and should be infused over at least 5 minutes (2-4 ml/minute). The solution can be mixed with 50-100ml of saline solution. A dose of sodium nitrite (300mg) should not increase the methemoglobin level above 30-40%. Blood pressure must be monitored closely and the infusion rate reduced if a drop in blood pressure becomes apparent. A drop in blood pressure should be treated with a volume of 10-20ml/kg body weight of saline solution, and the patient should be placed in shock position. In the event of clinical shock, the administration of adrenergic substances should be considered.

Step 2: After administering 4-DMAP or sodium nitrite, sodium thiosulphate should be infused over a period of 10 minutes. The adult dose of sodium thiosulphate is 100mg/kg body weight.

Methemoglobinemia should only be treated if 4-DMAP or nitrite has been overdosed, or the diagnosis of cyanide poisoning has been revised. If signs/symptoms of poisoning persist or recur, the administration of sodium thiosulphate should be repeated one hour later at 50% of the initial dose. In the event of seizures, 5 mg of diazepam or alternative benzodiazepines may be administered intravenously.
All patients should/must be transported to a hospital with intensive care facilities.

Sodium thiosulphate can also be administered to symptomatic, non-critical and non-unconscious patients with suspected cyanide poisoning. However, it should be noted that patients without impaired consciousness should not receive either 4-DMAP or sodium nitrite.

4.6. Further procedure and treatment

In addition to medical history, physical examination and vital signs, arterial blood gases, hemoglobin and methemoglobin levels, venous oxygen content and cyanide blood levels should be determined. A chest X-ray should also be performed.
After treatment with 4-DMAP or sodium nitrite, serum methemoglobin levels should be monitored. A methemoglobin level of 30-40% should not be exceeded if there is no anemia.
Signs of cyanosis occur at methemoglobin concentrations of approximately 15% or higher. In case of overdose or incorrect use of the methemoglobin-forming agent, methemoglobinemia must be treated. Methylene blue or toluidine blue are available as specific antidotes. All patients who have been treated with systemic antidotes for amine nitrile poisoning/exposure must remain in intensive care for at least 24 hours.

4.7. Laboratory tests

The diagnosis of cyanide poisoning is based primarily on the clinical picture with rapidly onset central nervous and cardiopulmonary symptoms and known or suspected very probable cyanide exposure. Laboratory tests are useful for monitoring the course of poisoning and early detection of complications. Routine laboratory tests should include complete blood count, glucose and electrolytes. After treatment with 4-DMAP or sodium nitrite, methemoglobin levels must be monitored closely.

Arterial blood gas concentrations should be determined to assess acid-base status, oxygen saturation and oxygen uptake. Pulse oximetry is not sufficient. Additional tests include ECG monitoring and serum lactate determination.

Metabolic acidosis should be treated with bicarbonate if the blood pH falls below 7.15. Care should be taken to ensure the timely detection and treatment of electrolyte imbalances (e.g. high potassium

concentrations, hypercalcemia).

4.8. Discharge of the patient / instructions for further rules of conduct

Patients who have been exposed to only minor amounts of cyanide, have not ingested cyanide, have not received antidotes, and show no abnormal clinical findings or signs of toxic effects after an appropriate follow-up period may be discharged under the following circumstances:

- The attending physician is experienced in assessing patients with cyanide exposure.
- Information and recommendations for patients with instructions for further action have been provided verbally and in writing. The patient has been instructed to seek immediate medical attention if any health problems arise.
- The patient is aware of and understands the toxic effects of cyanides and the instructions given regarding further rules of conduct
- The attending physician has been informed that regular contact between the patient and the physician is possible in the following 24 hours.
- Heavy physical work should not be carried out in the following 24 hours.
- Do not smoke for at least 72 hours and avoid cigarette smoke; smoke can impair lung function.

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