

Chemical Warfare

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Lecture Objectives:-

- ▶ Understanding what is chemical warfare
- ▶ Differentiating between different chemical agents
- ▶ Understand what is and the effect of gases like Sarin, Mustard gas, Chlorine , Hydrogen Cyanide and Lastly Phosphorus poisoning

What is chemical warfare?

- ▶ It is the **ACTION** of using **CHEMICALS** to cause intentional harm and death
- ▶ They are considered weapons of **MASS** destruction and thus they are forbidden by international law. However, despite these prohibitions, the use of chemical warfare has a historical precedent such as during **WW1** and **Syria**. unfortunately, it continues to be a troubling reality even today with what we see in **Gaza** (the usage of Phosphorus rockets).



Types of chemical agents

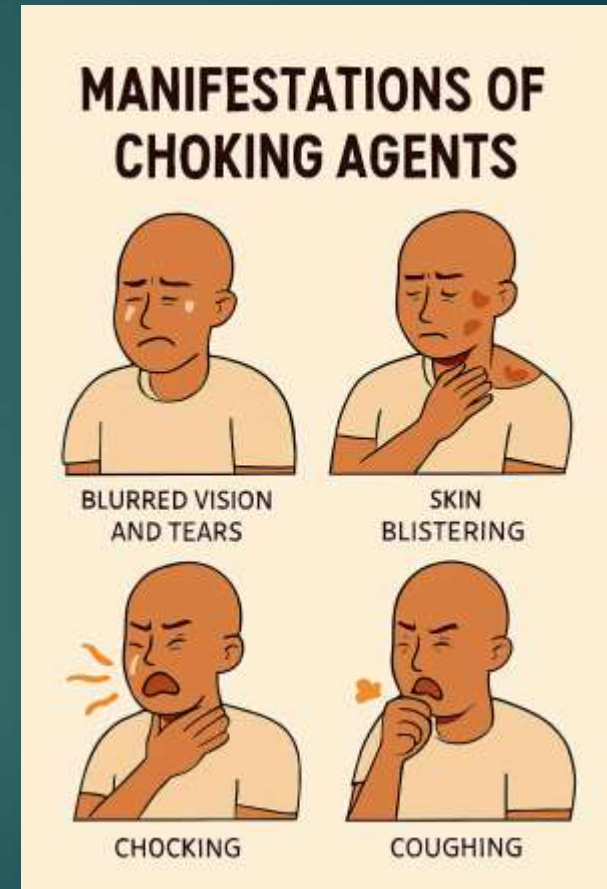
- ▶ Chemical agents can produce a variety of severe effects such as blistering, vomiting and even hallucinations and we can categorize them into different types of agents like:-

- 1) Choking agents
- 2) Blister agents
- 3) Blood agents
- 4) Nerve agents
- 5) Riot control agents

Choking agents

- ▶ Choking agents or pulmonary agents are chemical when inhaled cause fluid build up in the lungs and as you probably might have guessed. This will impede the ability to breathe and cause suffocation
- ▶ The **effects** of these agents are as follow:-
 - 1) blurred vision and tears
 - 2) Skin blistering
 - 3) Choking ,coughing , chest tightness losing consciousness and even **death**

Ex :- Chlorine , Phosgene and Diphosgene



Blister agents

- ▶ Also known as Vesicant agents that Cause severe chemical burns (blisters) by **inhalation or contact or ingestion**
- ▶ The **effects** of these agents are as follow:-
 - 1) Large blisters on the skin
 - 2) Conjunctivitis and corneal damage
 - 3) The effect on Respiration ranges from mild to moderate
- ▶ **Nettle agent (Urticants): a variant that only causes irritation, erythema and itching**
- ▶ **Ex :- Sulfur Mustard, Nitrogen Mustard**



Blood agents

- ▶ Blood agents work by preventing the exchange of oxygen and carbon dioxide between the blood and the body's cells they cause their effects by inhalation or ingestion
- ▶ The **effects** of these agents are as follow :-
- ▶ **Mild to Moderate Exposure** (Headache , fatigue , confusion, flushing of the skin or cyanosis)
- ▶ **Severe Exposure** (Rapid breathing , abdominal pain Loss of consciousness or coma hypotension, cardiovascular failure and **death**)
- ▶ Ex:- : Hydrogen Cyanide , Cyanogen Chloride and Arsine

Nerve agents

- ▶ Are **Irreversible** acetylcholinesterase inhibitors used as poisons , so naturally acetylcholine will accumulate and cause a “**cholinergic crisis**”.
- ▶ The **effects** of these agents are as follow:-
 - 1) Constriction of the pupils
 - 1) Muscle spasms
 - 2) Salivation , sweating and tearing
 - 3) Bradycardia and bronchoconstriction (**could cause cardiac arrest**)
 - 4) Urinary incontinence and defecation
 - 5) Seizures

Nerve agents cont.

- ▶ We can sub-classify nerve agents into :-
- ▶ G-agents : like Sarin are
- ▶ non-persistent—they Evaporate quickly and act fast through inhalation
- ▶ V-agents : like VX are persistent, staying on surfaces longer and causing harm mainly through skin exposure.



Example agents

- Tabun (GA)
- Sarin (GB)
- Soman (GD)
- Cyclosarin (GF)
- VX

Dispersal

Liquid, aerosol, vapour and dust

Mode of Action

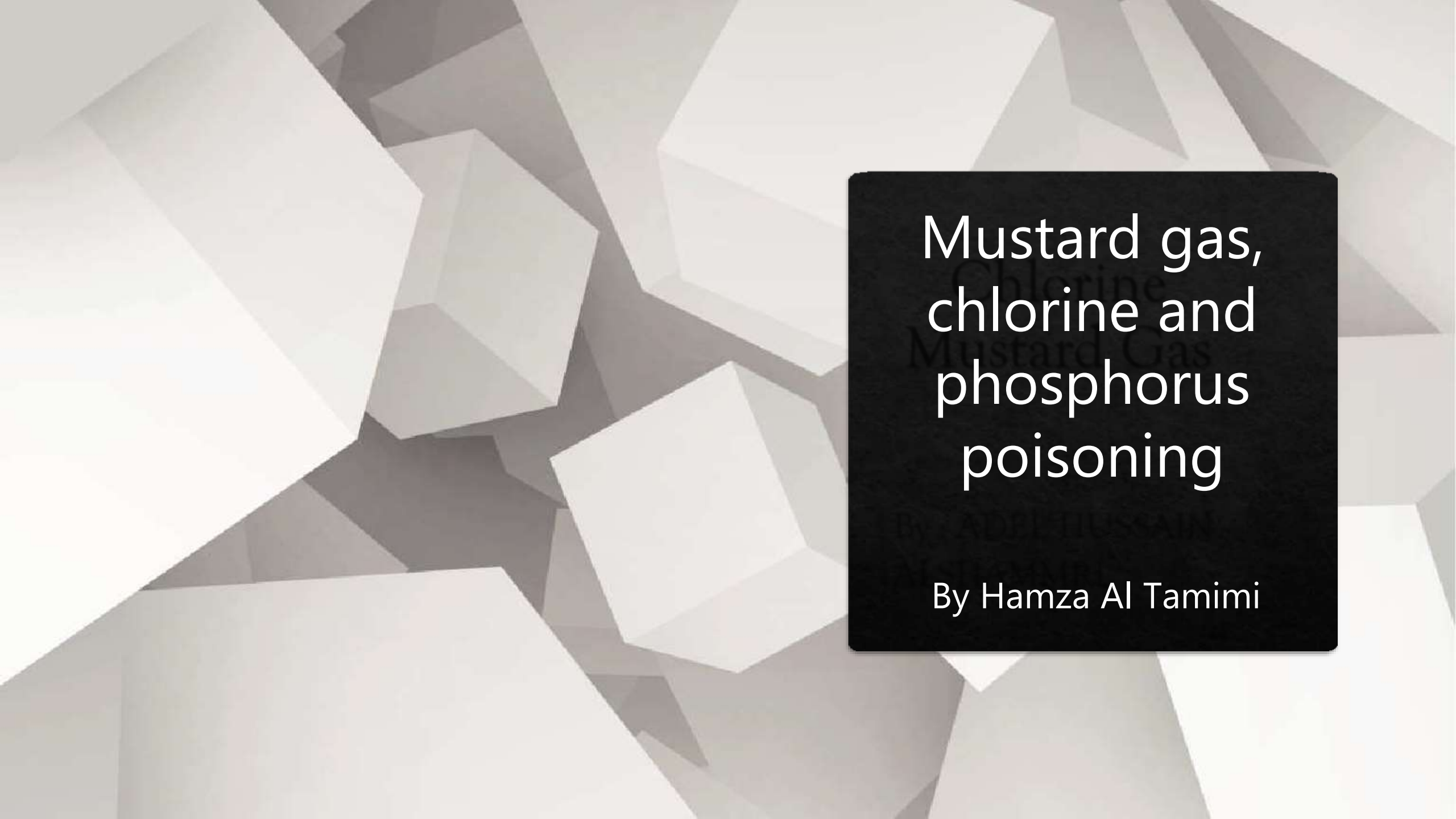
Absorption through lungs (G-series); contact with skin (VX)

Effects

Causes seizures, loss of body control; paralyzes muscles, including heart and diaphragm

Riot control agents

- ▶ Are chemical compounds that temporarily make people unable to function by causing irritation to the eyes , mouth, throat, lungs, and skin
- ▶ Temporarily (15–30minutes) hinder function
- ▶ The **effects** of these agents are as follow:-
 - 1) Burning of the eyes and tearing
 - 2) runny nose
 - 3) Burning of the mouth , dysphagia , drooling
 - 4) Chest tightness , choking sensation , wheezing and shortness of breath
 - 5) Skin rash and even burns
 - 6) Nausea and vomiting
- ▶ **Ex: tear gas and pepper spray**



Mustard gas, chlorine and phosphorus poisoning

By Hamza Al Tamimi

Chlorine

- Chlorine gas represents a hazardous material threat from industrial accidents and used as a terrorist weapon.
- It's a **Green-yellowish** gas with a pungent, irritating odor, and density higher than air; it tends to settle along the ground.
- **Toxicity depends on:**
 - (1) concentration
 - (2) Duration
 - (3) exposed tissue.
- **Toxic** only in high doses (**>10** ppm).



Clinical manifestation of chlorine toxicity

- Most serious clinical effects of chlorine toxicity tend to be **pulmonary(choking agent)**:

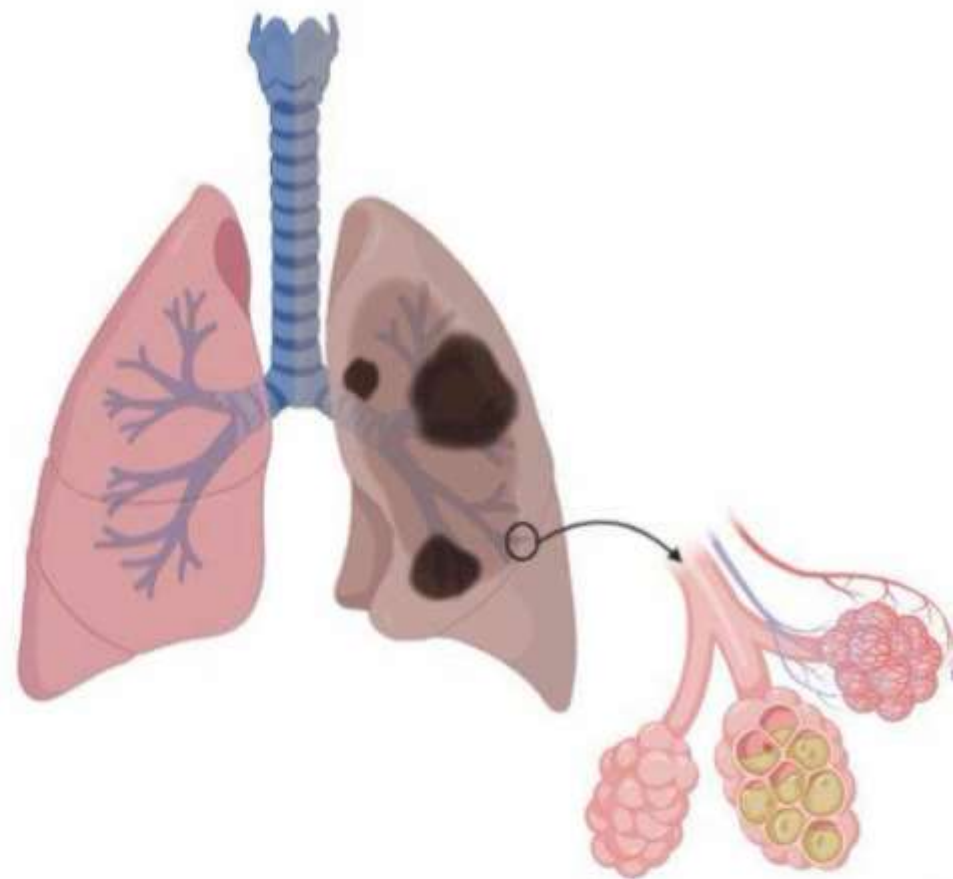
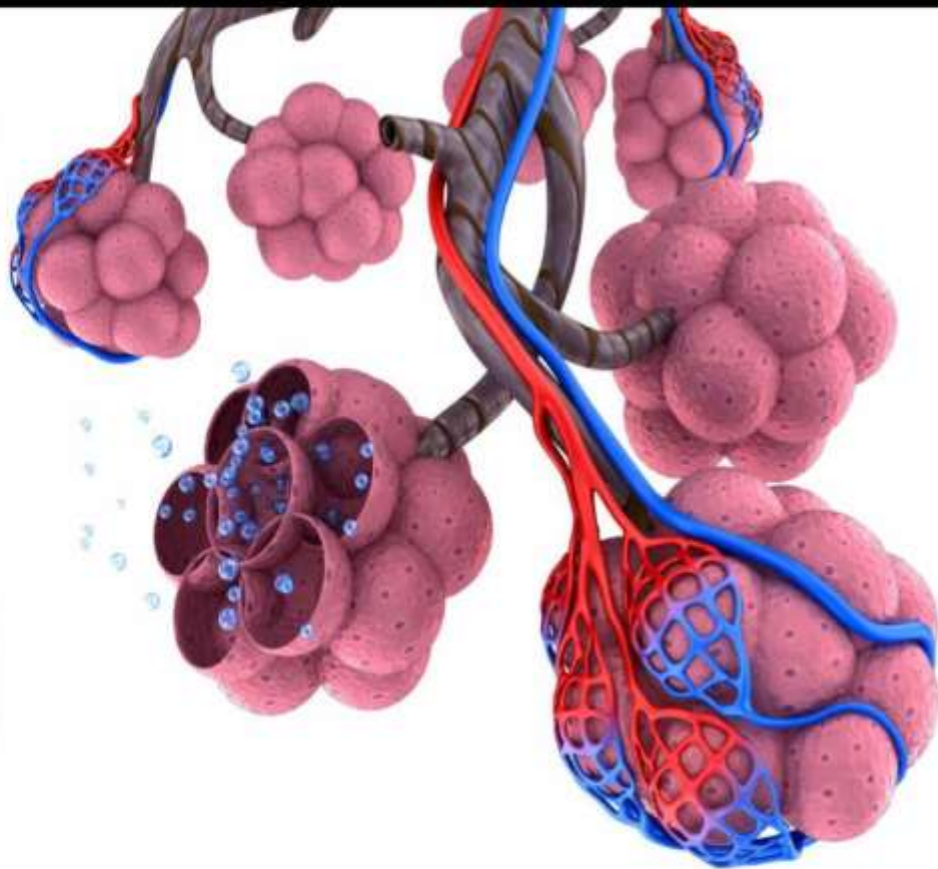
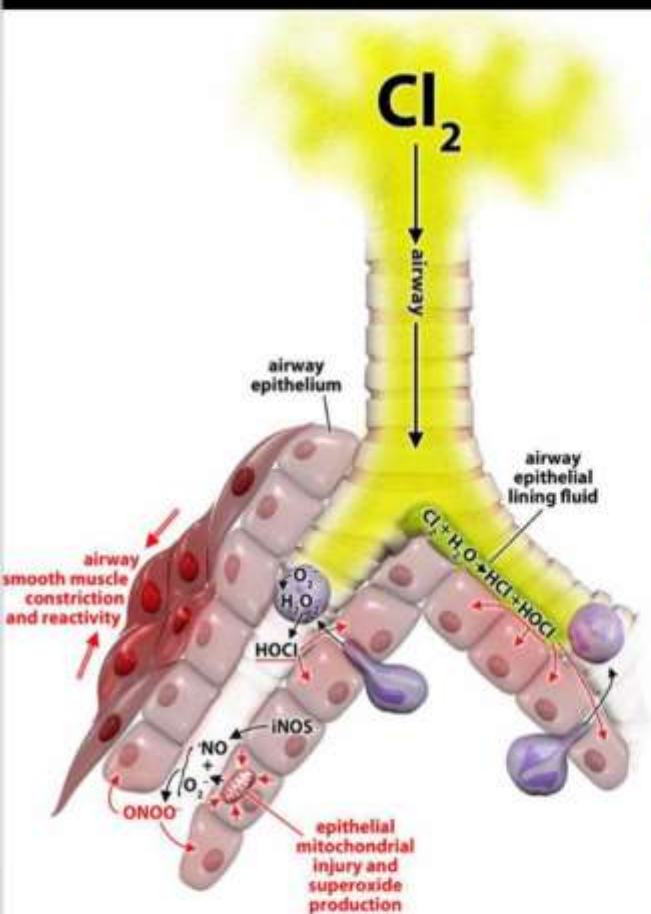
1-local irritation from acid results in an **inflammatory response** of the upper and lower airways leading to **bronchospasm**;leading to **cough and dyspnea**.

2-**disruption** of cell membranes and proteins by the acids and free radicals results in **death of alveolar cells and endothelial cells** of the adjacent capillaries;leading to **pulmonary edema** and **Acute Respiratory Distress Syndrome**.

- It can also cause **skin and eye** injuries:

Dermal manifestations include irritation and pain,and severe exposure leads to chemical burns including blister formation.

Ocular complications include irritation and conjunctivitis.



Management and treatment

- **Decontamination(first step):**

Involves evacuation of the patient from the area of exposure,remove clothing,irrigating with copious amounts of water for 20-30 min and soap.

- **Supporting the patients breathing using O2 and bronchodilators:**

Asses the patients airways,breathing,circulation,and provide humified oxygen as necessary,severe exposure may indication endotracheal intubation.



White phosphorus

- Is a toxic substance used in industry and in **military bombs**.
- **Ignites** spontaneously with air and **burns** fiercely, emits **bright light** and irritating **thick white fumes**.
- Works mainly as a choking agent AND causes **severe chemical + THERMAL burns** that keep burning as long as particles are in contact with air; must be removed and cooled immediately; which makes it **more hazardous** and dangerous than chloride.
- Uses in military include; fires, cover, choking.
- Banned under international law for use against civilians and populated areas.



Mustard Gas (sulfur mustard)

- ◆ Synthetic **Blister** agent.
- ◆ The impure form used in chemical **warfare** is **yellow-brown** in color when liquid-odor like **mustard/garlic/horseradish** density higher than air.
- ◆ Among the blistering chemical warfare agents (CWA), sulfur mustard is the most important since it is known as the **"King of chemical warfare agents"**. The use of sulfur mustard has caused serious damages in several organs, especially the eyes, skin, respiratory, central and peripheral nervous systems after **short** and **long term** exposure, incapacitating and even killing people.





Clinical Manifestation

- ◆ The first exposure to sulfur mustard is often without pain. People smell only a little garlic or sulfur odor. Naturally, **symptoms will be shown for several hours**. The maximum severity of symptoms appears after a few days.
- ◆ The most sensitive organs during exposure to sulfur mustard are **eyes**.
- ◆ After ophthalmologic lesions of sulfur mustard exposure, **respiratory** symptoms are seen. These complications happen before skin lesions appear .
- ◆ **Skin** is an important vulnerable tissue to sulfur mustard. Various factors such as **temperature, humidity and anatomical position** determine the type of injuries and intensity of symptoms.



Signs & Symptoms of Exposure to Sulfur Mustard

Exposure to sulfur mustard **is usually not fatal**, however, it can cause **long term health effects**, including **cancer**. You may not know right away that exposure to sulfur mustard has happened as there may or may not be a smell or chemical odor. If you handle discarded military munitions, it is recommended that you follow up with a healthcare provider, even if you do not think you have been exposed.

You may not have signs or symptoms immediately after exposure—they **may appear up to 24 to 48 hours later**. If you or a coworker are exposed to liquid from the munition, rinse your eyes thoroughly with clean water for at least 20 minutes and wash your skin and hair with soap and water being careful not to scratch or break the skin and to seek immediate medical attention.

Sulfur mustard can have the following effects:

SKIN: redness and itching of the skin (2 to 48 hours after exposure); may change to yellow blisters.

EYES: irritation, pain, swelling, and tearing (3 to 12 hours after a mild to moderate exposure; 1 to 2 hours after a severe exposure). Severe exposure may also lead to light sensitivity, severe pain, or blindness lasting up to 10 days. ✖

RESPIRATORY: runny nose, sneezing, hoarseness, bloody nose, sinus pain, shortness of breath, and cough (12 to 24 hours after a mild exposure; within 2 to 4 hours of a severe exposure).

DIGESTIVE: abdominal pain, diarrhea, fever, nausea, and vomiting.

BONE Marrow: decreased formation of blood cells (aplastic anemia) or decreased red or white blood cells and platelets (pancytopenia) leading to weakness, bleeding, and infections.

Treatment

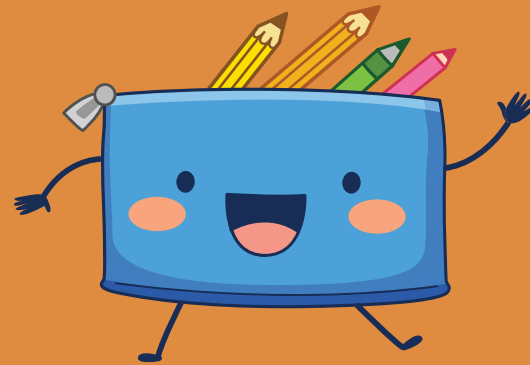
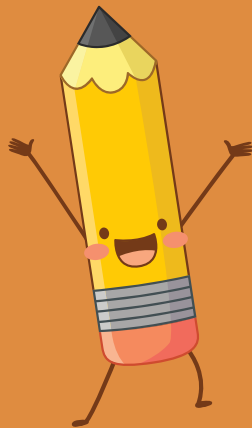
- ◆ When exposure to sulfur mustard is suspected, immediate **decontamination**, including removal of clothing and scrubbing with soap and water, is needed immediately. Management is largely **symptomatic treatment** and **supportive care**. Historical treatments such as topical bicarbonate solution and chlorinated soda are less beneficial than soap and water. Cutaneous burns are managed similarly to thermal burns with **debridement**, **antibiotic ointment**, **collagen**-laminated nylon **dressings**, **hydrogel dressings**, and fluid resuscitation, as needed

↓
IV



Sarin and hydrogen cyanide

DONE BY : ALI AL-MAHARMEH



Sarin gas



- Nerve agent.

Synthetic organophosphorus compound.

- Colorless, odorless and tasteless liquid.

- Higher density than air.

- ♣ -Lethal even in small doses (35 mg per cubic meter)

- In non-lethal doses may cause permanent neurological damage.

- Has high volatility and can penetrate skin. ♣

- Can contaminate water, food, clothes.

Sarin gas

Mechanism of action:

Inhibit
acetylcholinesterase



Ach accumulation



Cholinergic crisis

Sarin nerve gas

The man-made nerve agent was originally developed as a pesticide in Germany in 1938 but developed further during World War Two. Claims that Syria has used sarin have raised questions about the deadly nerve gas and how it affects the body.

Sarin attacks the nervous system, interfering with signals between the central nervous system and muscle fibres

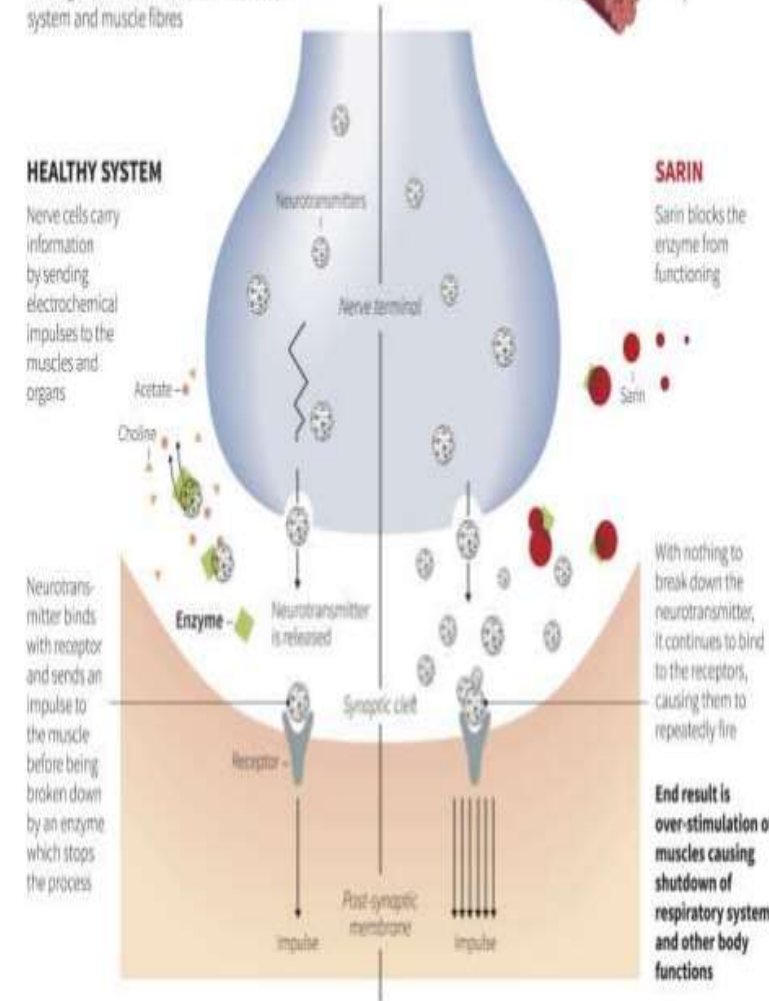
Neuromuscular junction

A connection between the nervous and muscular systems



HEALTHY SYSTEM

Nerve cells carry information by sending electrochemical impulses to the muscles and organs



SARIN

Sarin blocks the enzyme from functioning

With nothing to break down the neurotransmitter, it continues to bind to the receptors, causing them to repeatedly fire

End result is over-stimulation of muscles causing shutdown of respiratory system and other body functions

Sarin gas

Miosis is very important sign for Sarin gas or organophosphorus compounds exposure

Runny nose

Watery eyes

Small, pinpoint pupils

Eye pain

Blurred vision

Drooling and excessive sweating

Cough

Chest tightness

Rapid breathing

- **Diarrhea**

- **Nausea, vomiting, and/or abdominal pain**

- **Increased urination**

- **Confusion**

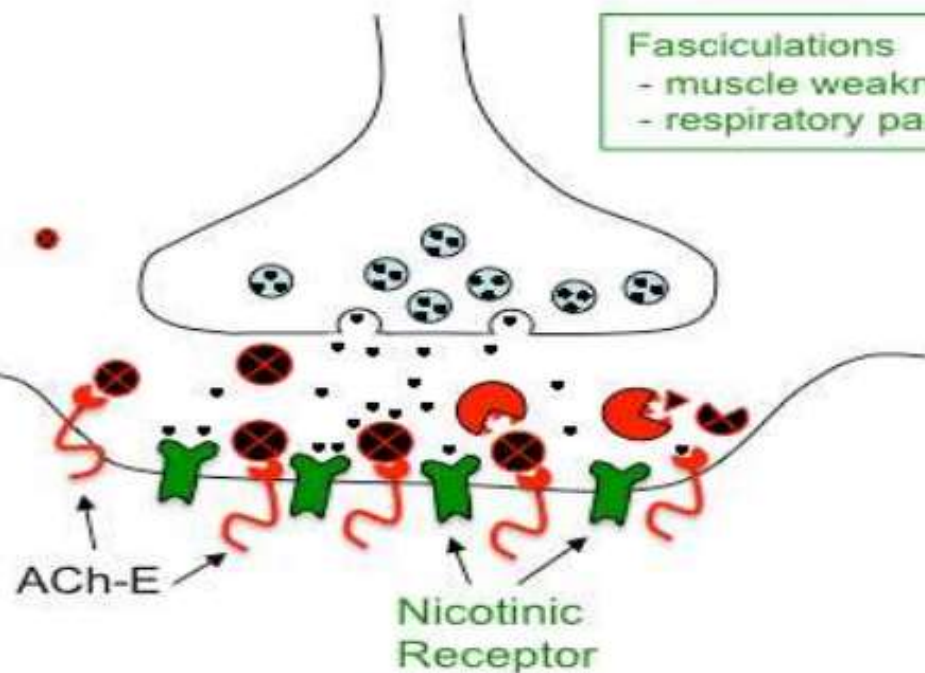
- **Drowsiness**

- **Weakness**

- **Headache**

Nicotinic Sites

Fasciculations
- muscle weakness
- respiratory paralysis



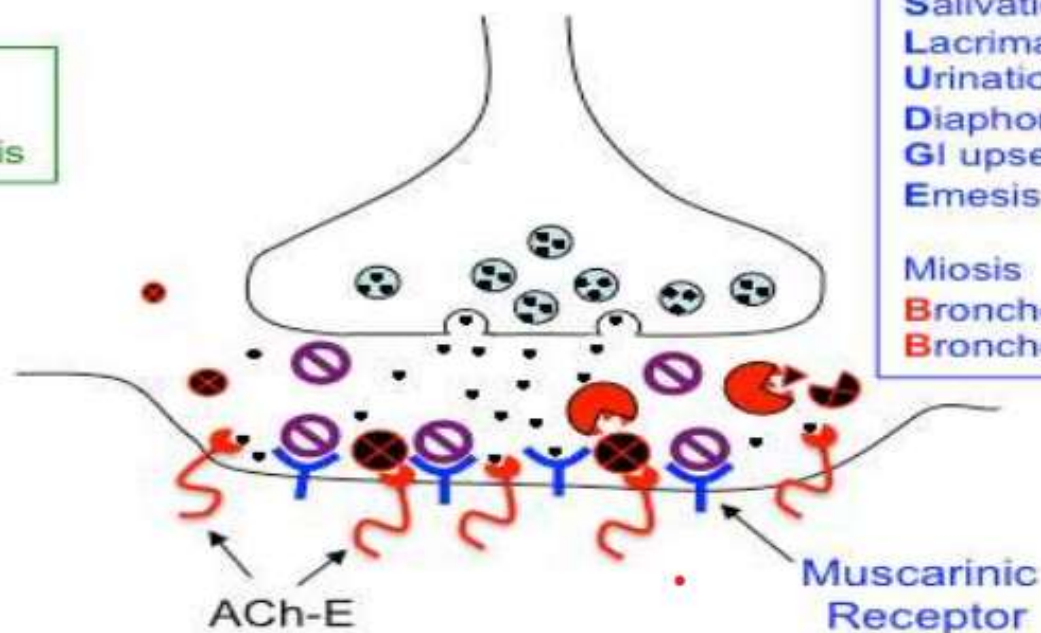
2-PAM

Sarin

Muscarinic Sites

Salivation
Lacrimation
Urination
Diaphoresis (sweating)
GI upset (diarrhea)
Emesis

Miosis
Bronchoconstriction
Bronchorrhea
"Killer B's"



Atropine

2-PAM

Sarin

CNS effects :
mixed nicotinic
& muscarinic



seizures

Rx:
Benzodiazepines
Scopolamine

Summary:

- Sarin inhibits AChE at both nicotinic & muscarinic synapses
- Pralidoxime (2-PAM) can regenerate AChE at both nicotinic & muscarinic synapses
- Atropine reduces symptoms of cholinergic excess at muscarinic sites only
- Scopolamine & benzodiazepines (e.g. diazepam, lorazepam or midazolam) for CNS symptoms



Sarin gas

- Exposure to large doses of sarin by any route may result in the following harmful health effects:
- Loss of consciousness
- Convulsions
- Paralysis
- Respiratory failure possibly leading to death



➤ Management:

➤ 1 - Leave the area

- Go to the highest ground possible
- Cut off clothes and dispose properly
- Wash your entire body with water
- ABC
- Suctioning and endotracheal intubation may be required - Gastric lavage

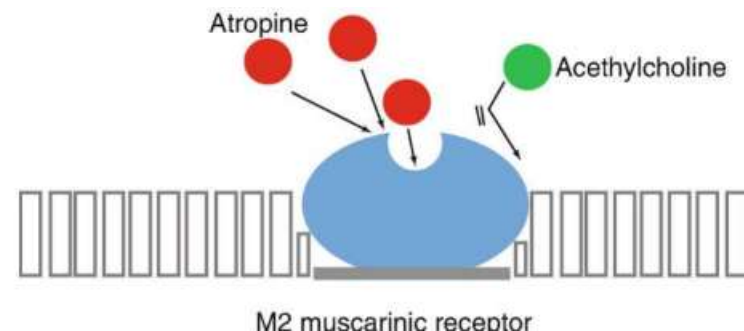
➤ Treatment:

- administer antidote (atropine/pralidoxime/biperiden)

Sarin (GB) treatment

Atropine is the specific antidote for organophosphorus compounds

(1) Atropine. Give 0.5–2 mg IV initially (p 450) and repeat the dose as needed. Initial doses may also be given IM. The most clinically important indication for continued atropine administration is persistent wheezing or bronchorrhea. Note: Atropine will reverse muscarinic but not nicotinic (muscle weakness) effects.



Cont

- ➡ (2) Pralidoxime is a specific antidote for organophosphorus agents. It should be given immediately to reverse muscular weakness and fasciculations as a 1- to 2-g initial bolus dose (20–40 mg/kg in children) IV over 5–10 minutes, followed by a continuous infusion. It is most effective if started early, before irreversible phosphorylation of the enzyme, but may still be effective if given later. Initial doses can be given by the IM route if IV access is not immediately available.
- ➡ (3) Diazepam. Anticonvulsant therapy may be beneficial even before the onset of seizures and should be administered as soon as exposure is recognized. The initial diazepam dose is 10 mg IM or IV in adult patients (0.1–0.3 mg/kg in children)

Aging

○

Once sarin binds to cholinesterase the chemical stability of **its interaction with the enzyme can become irreversible with time due to the loss of an alkyl group**. When this happens it's binding becomes irreversible (**aging**) and the becomes resistant to the effects of oxime regenerators such as **pralidoxime**

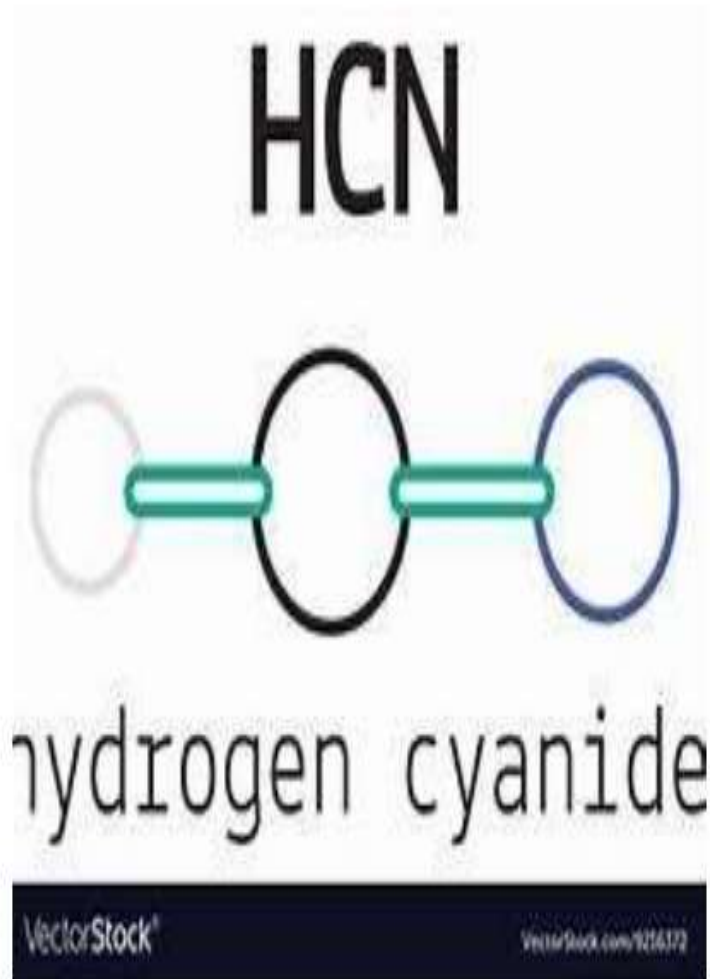
Aging develops with a half-time of 5 hours with sarin.

○



HCN

Hydrogen Cyanide

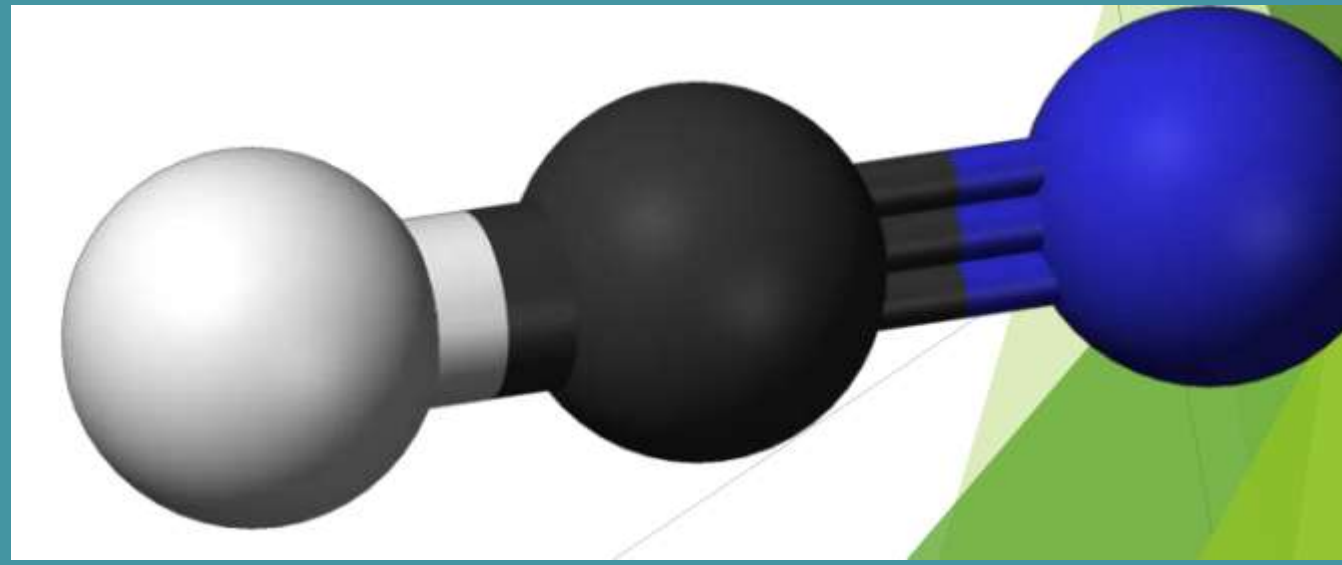


Hydrogen Cyanide

- ▶ Synthetic Blood agent.
 - ▶ Colorless liquid compound.
 - ▶ sometimes is described as having a “bitter almond” smell.
less dense than air.
 - ▶ Need large concentrations.
 - ▶ Impractical in field use.
-
- ▶ affect the body by:
 - ingestion (delayed onset)
 - inhalation (rapid onset)
 - skin contact (delayed onset)

Hydrogen Cyanide

➡ Mechanism of action:



Hydrogen Cyanide

Exposure to **small** amount:

Dizziness

Headache

Nausea and vomiting

Rapid breathing

Rapid heart rate

Restlessness

Weakness

- Exposure to large amount:
- Convulsions
- Loss of consciousness
- Low blood pressure
- Lung injury
- Respiratory failure leading to death
- Slow heart rate
- Deep com



Hydrogen Cyanide

Management:

- Leave the area
- Go to the ((lowest)) ground possible
- Cut off clothes and dispose properly
- Wash your entire body with water and soap



Treatment:

- administer antidote
- - supportive O2 supplementation.



Hydrogen Cyanide

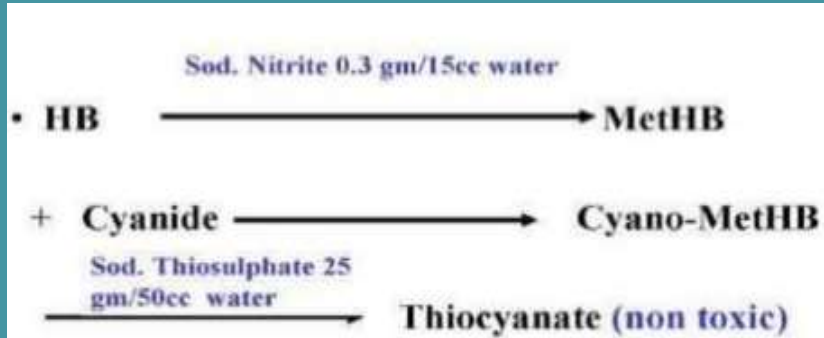
Hydroxocobalamin (vitamin B12a):

- ➡ - given IV or IM.
- converts cyanide to the much less toxic cyanocobalamin.
- Cyanocobalamin is renally cleared.
- first line therapy for people with cyanide poisoning due to:

- (1) low adverse risk profile
- (2) rapid onset of action
- (3) ease of use in the prehospital setting



Hydrogen Cyanide



Antidote Kit:

- contains:

- (1) amyl nitrite
- (2) sodium nitrite
- (3) sodium thiosulfate

- works by:

- (1) competing for cyanide with cytochrome a₃
- (2) remove the cyanide from the body is by enzymatic conversion to thiocyanate

**THANK
YOU**