TOXICOLOGY NOTES

Chemical & Radiation Exposure

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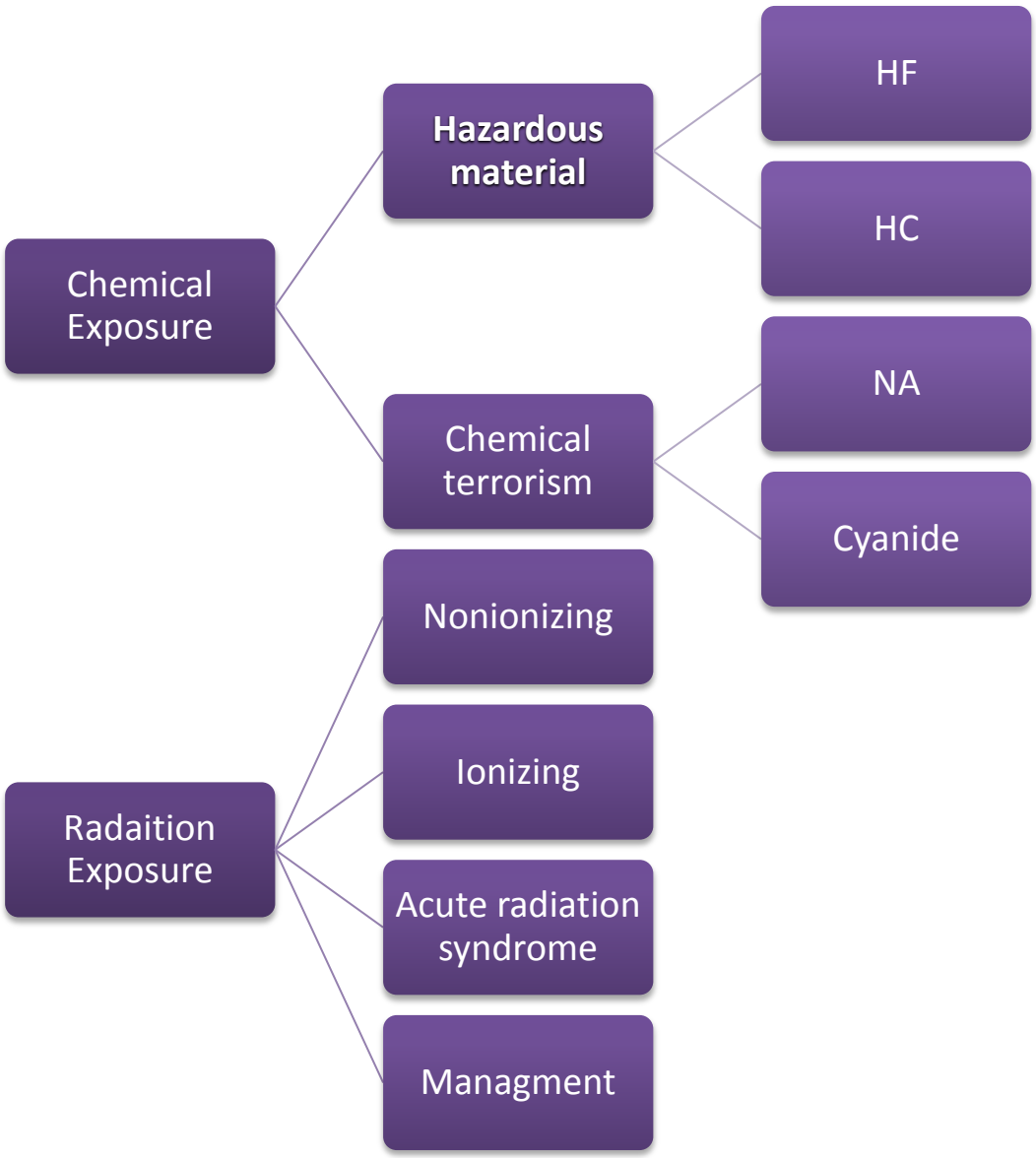
COLOR GUIDE: • Females' Notes • Males' Notes • Important • Additional

Objectives

Were not given.



Hazardous material (hazmat):

Is defined as any substance, including gases, solids, or liquids, that has the potential to cause harm to people or the environment.

1- What are the mechanism involved in injuries?

- **Direct Chemical reaction.**
- **Hyperthermic (exothermic reaction)**

Most chemical agents cause skin damage by producing a chemical reaction rather than a hyperthermic injury. Certain chemicals can generate significant heat production via an exothermic reaction. Nonetheless, the majority of dermal injuries result from direct damage to the skin rather than from a hyperthermic injury.

2- What are the determinants of the degree of injury?

- **Concentration.**
- **Duration of exposure .**
- **Anatomical weaker body parts (Areas of thin skin).**

Note(s):

Employees working with chemicals (labs, manufactories…etc.) are more likely to be injured, followed by the general public.

Skin that is particularly thin or broken can contribute to more severe injury.

3- What are the differences between Acidic & Alkalic injuries?

Upon interaction with skin:

- **Acids: Cause protein denaturation & coagulative necrosis →Eschar formation. ALKALI IS MORE DANGEROUS**
- **Alkali: Saponification and liquefactive necrosis of body fat.**

Note(s):

When acidic compounds interact with skin, protein denaturation and coagulative necrosis ensue. This coagulative necrosis produces an eschar, which limits the depth to which the acid can penetrate. Despite this eschar formation, acidic burns can, nonetheless, produce profound burns.
Unlike the coagulative necrosis produced from most acids, alkalis produce saponification and liquefactive necrosis of body fat. Because there is no eschar to limit penetration, alkali burns tend to penetrate deeper into the tissues, which results in significant tissue damage.

4- Coping with Hazmat incidents:

- Securing Scene, implementation of site plan & evacuation.

Which involves containing the substance, extinguishing fires, and controlling other environmental hazards.

- Treatment, which starts with decontamination.

Decontamination begins by removing the patient's contaminated clothes. Liquid chemicals can be copiously irrigated directly. Ideally, the contaminated water will be contained on the scene for appropriate disposal. If decontamination was indicated and not performed on the scene, the patient should be decontaminated before entering the ED.

5- General Management Principals:

- Remove from hostile environment.
- Remove cloths.
- Decontaminate (wounds → eyes → mucus membranes → skin → hair).
- Goal is to normalize skin PH.
- Hydrotherapy.

Note(s):

Chemical burns continue to destroy tissue until the causative agent is inactivated or removed. Therefore the more quickly the agent removed from the skin, the less severe the injury.

Hydrotherapy involves the application of large amounts of water or saline to the affected skin. Gentle irrigation of a large volume of water under low pressure for a prolonged time dilutes the toxic agent and washes it out of the skin. High-pressure irrigation should not be used because it is possible to drive the chemical deeper into the skin. Furthermore, the use of high-pressure irrigation can result in splattering of the chemical into the eyes of the patient or rescuer.

Hydrofluoric Acid

- Acidic aqueous solution.
- Used in the petroleum industry, removing rust, and cleaning cement and bricks.
- Absorption from lungs, skin, and eyes.
- Liquefactive necrosis, similar to alkalis.
- Free fluoride ion is responsible for the injury.
-

Mechanism of action:

- Scavenges cations, such as Ca+ & Mg.
- Cause systemic hypocalcemia & hypomagnesemia.
- inhibit (Na+,K+-ATPase) & the Krebs cycle
- Causes Hyperkalemia, a preterminal finding.
- QT prolongation, hypotension, and ventricular arrhythmias

Note(s):

The free fluoride ion scavenges cations, such as calcium and magnesium, thereby resulting in systemic hypocalcemia and hypomagnesaemia. In addition, free fluoride ions can inhibit sodium, potassium– ATPase (Na+,K+-ATPase) and the Krebs cycle. The combination of cellular destruction and inhibition of Na+,K+-ATPase can also result in hyperkalemia, a preterminal finding. As a result of the numerous electrolyte disturbances, QT prolongation, hypotension, and ventricular arrhythmias can occur. The severity of injury depends on the concentration of the substance and the duration of exposure

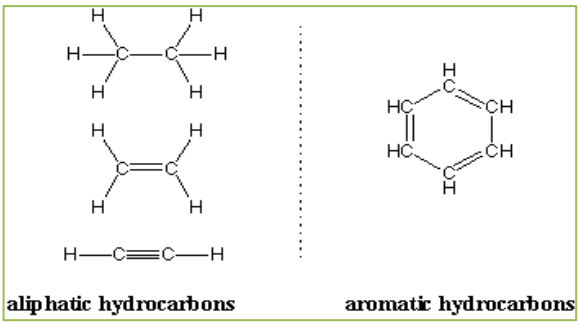
Type of exposure	Inhalational Exposure	Gastrointestinal Exposure	Ocular Exposure	Dermal Exposure
Occurrence	Rare	Rare	-	**Most common.**
Symptoms	Inhalation and skin exposure to 70% HF can result in pulmonary edema and death within 2 hours.	Leads to life threatening toxicity.	-Severe burn with penetration and necrosis of the structures throughout the anterior chamber. -Irrigation is the key!!	- Progressive tissue destruction & Intense pain can occur quickly or be delayed for several hours to days if not treated. - Eschar, whitish appearance with vesicle.
Therapy	› Irrigation for 15 to 30 minutes. › blister removal. › Detoxification Locally, Infiltration or Intra-arterial infusion of Ca. Gluconate. (Calcium gel is the preferred topical agent)			

Hydrocarbons

Found in fuels, solvents, paints, paint and spot removers, dry cleaning solutions, lamp oil, rubber cement, and lubricants.

HC: Classification:

- Aromatic: Carbon arranged in a ring.
- Aliphatic: Carbon arranged in a linear or branched chain.



HC: Mechanism of action:

- Lungs (aspirations) are the most common organ affected.
- Systemic toxicity from dermal exposure is rare.
- Perioral or perinasal dermatitis with pyoderma. This so-called "huffer's rash". (Those who sniff pain or gas)
- Ingestion of hydrocarbons can result in aspiration and systemic toxicity.
- Substances with high volatility, low viscosity, and low surface tension are the most toxic.

HC: Management

- Remove offending agent.
- Irrigation.
- Airway management.
- Bronchodilators.
- Observation for minimum of 6 h after ingestion.

CHEMICAL TERRORISM

I. Nerve agents.
II. Cyanide and related toxins.
III. Vesicants (Blistering agents).
IV. Choking agents.

I. Verve agents:

- The primary mechanism of action of the nerve agents is to prevent acetylcholinesterase from hydrolyzing ACh.
- Primary clinical toxic effects are respiratory.

Nicotinic Receptors:

Muscle fasciculations and weakness.

Muscarinic receptor:

DUMBELS	SLUDGE
Diarrhea **U**rination **M**icturation **B**ronchoconstriction/Bronchorrhea **E**mesis **L**acrimation **S**alivation	**S**alivation **L**acrimation **D**iarrhea **G**astrointestinal **E**mesis

NA: Management:

- Decontamination with large-volume, low-pressure irrigation with water.
- Maintaining an airway and restoring adequate oxygenation and ventilation.
- Anti-muscarinic (Atropin), pralidoxime.
- Benzodiazepines for Sz. (seizures)

II. Cyanide:

- Cyanide salts and hydrocyanic acid are commonly used for metal cleaning, precious metal extraction, photographic processes, electroplating, laboratory assays, and jewelry cleaning,
- Combustion of Plastic-containing compounds.

Cyanide: Mechanism of action:

- Cellular toxin.
- Binds to both Fe3+ and cobalt.
- Inhibits oxidative phosphorylation.
- Cellular hypoxia and death.

Cyanide: Clinical picture:

- Sudden cardiovascular collapse.
- Coma.
- Profound metabolic acidosis.
- A characteristic odour of bitter almonds is frequently discussed but only rarely clinically noted.

Cyanide: Laboratory Testing:

- Levels are confirmatory.
- Lactic acidosis (profound).
- Normal SpO2% despite cellular hypoxia. (doesn't have general hypoxia, but has cellular hypoxia)

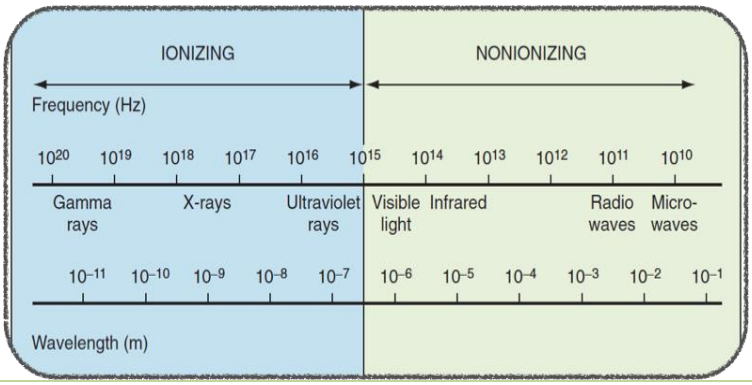
Cyanide: Management:

- Decontamination.
- PPE. (personal protective equipment, cyanide is very toxic)
- ABCD.
- Antiarryhthmics.
- Amyl nitrite, sodium nitrite, and sodium thiosulfate.
- Induce methemoglobinemia. Thiosulfate enhances transulfuration of hydrogen cyanide to thiocyanate, which is renally excreted.
- In December 2006, the Food and Drug Administration approved hydroxocobalamin (Cyanokit) for treatment of cyanide intoxication.
- Don't forget to address CO poisoning in burn (inhalation) victims!!

Radiation exposure!

Radioactivity: refers to the loss of particles (e.g., alpha, beta, or neutrons) or energy (e.g., x-rays and gamma rays) from an unstable atom that is spontaneously decaying.

Decay: The spontaneous transformation of an unstable isotope to a stable one, and it may involve the release of ionizing radiation.

Types of radiation	Ionizing	Nonionizing
Definition	Ionizing radiation has a short wavelength, high frequency, and high energy. The photons of ionizing radiation carry 1 billion times more energy than the photons of nonionizing radiation.	Nonionizing radiation has a long wavelength, low frequency, and low energy. As such, it does not carry enough energy to remove an electron from an atom and therefore does not produce charged ions on passing through matter.
Effect	Directly cause cell death or damages the DNA	The primary adverse effects of nonionizing radiation are related to local heat production
Example	Ionizing radiation is emitted in the form of alpha and beta particles, gamma rays, and x-rays.	light, radar, radio, microwave ovens.
For your information only		

Irradiation Vs.	Contamination Vs.	Incorporation
Object that is irradiated does not become radioactive	Radioactive contamination is a radioactive particulate matter (alpha and beta particles) on an exposed surface.	Incorporation occurs when a radioactive material is ingested, inhaled, or absorbed through an open wound.
post-radiation therapy patient, no hazard exists to medical personnel.	This radioactive particulate matter may emit radiation with an effect that is directly related to the time of exposure, distance from the source, and type of contamination.	-

Acute radiation syndrome

Is a symptom complex that occurs after whole-body irradiation. It varies in nature and severity by dose, dose rate, dose distribution, and individual susceptibility.

What is the earliest Indicator of a significant exposure?

Decrease in the absolute lymphocyte count, which can occur within 48 hours after exposure.

Prognosis According to the Lymphocyte Count within the First 48 Hours after Acute Exposure to Penetrating Whole-Body Radiation:

LYMPHOCYTE COUNT (per mm^2)	APPROXIMATE ABSORBED DOSE (Gy)	EXTENT OF INJURY	PROGNOSIS
1400-3000 (normal range)	0-0.4	No clinically significant injury	Excellent
1000-1499	0.5-1.9	Clinically significant but probably nonlethal	Good
500-999	2-3.9	Severe	Fair
100-499	4-7.9	Very severe	Poor
100	8	Most severe	High incidence of death even with hematopoietic stimulation

What is the LD50 or median lethal whole body dose?

The LD50 or median lethal whole-body dose (the dose that is lethal for 50% of test subjects), assuming proper medical care, is estimated to be approximately 4.5 Gy.

Radiation: Management:

- Reduce Exposure.(time, distance, and shielding)
- Decontamination.
- Effective ED preparedness (Involve radiation control officer).
- Geiger-Mueller instrument for monitoring the environment.
- ABCD's & Supportive measures.
- Chelating agents for Internal contamination.

MEDICATION	RADIOACTIVE ISOTOPE
Ferric hexacyanoferrate (Prussian blue)	Cesium-137, thallium
Ca- and Zn-diethylenetriaminepentaacetate (DTPA)	Plutonium, americium, curium
Potassium iodide	Radioiodine
Penicillamine	Radioactive heavy metal poisoning (lead)

SUMMARY

1. Hazmat.

- For chemical injury, the degree of skin destruction is determined mainly by the properties of the toxic agent, its concentration, and the duration of its contact
- Chemical injuries are commonly encountered after exposures to acids and alkalis.
- In dealing with hazmat incidents, two distinct goals must be achieved: (1) The hazmat must be contained, fire and explosions should eventually be extinguished, and the site must eventually be cleaned, and (2) people exposed to the hazmat must be treated.
- Alkali burns tend to penetrate deeper than acidic burns; as a result, alkali burns tend to be associated with greater morbidity.
- HF burns can be associated with significant hypocalcemia.
- Unconventional chemical weapons may be categorized into four major classifications: nerve agents, vesicants, choking agents, and cyanide agents.

2. Radiation exposure:

- Contaminated patients are “radioactive”; irradiated patients
- No danger to medical personnel from contaminated patients exists with proper precautions and decontamination procedures.
- Most therapy is supportive and symptomatic except for exposures involving the ingestion or inhalation of radioactive material, when specific therapy with blocking or chelating agents may be indicated.

Additional notes were taken from Rosen Emergency Medicine, 8th Edition.

Questions

1) Characteristics of hydrofluoric acid:

a. Causes liquefactive necrosis, bluish appearance with vesicle
b. The most common exposure is inhalational.
c. Causes hypercalcemia.
d. Free fluoride ion is responsible for the injury.

2) The most toxic Hydrocarbons are :

a. low volatility, low viscosity, and low surface tension are the most toxic
b. high volatility, high viscosity, and high surface tension are the most toxic
c. high volatility, low viscosity, and low surface tension are the most toxic
d. low volatility, high viscosity, and high surface tension are the most toxic

3) Diagnostic of cyanide toxicity:

a. Odor of sweet almonds.
b. Positive History +Profound hypocalcaemia
c. Positive history +profound metabolic acidosis

4) Prognosis According to the Lymphocyte Count within the First 48 Hours after Acute Exposure to Penetrating Whole-Body Radiation:

a. Lymphocyte Count 800, excellent
b. Lymphocyte Count 250, fair prognosis
c. Lymphocyte Count 1200, good prognosis

Answers:

1st Questions: D

2nd Questions: c

3rd Question: C

4th Question : c