

L14: Chemical and Radiation Exposure

مقدمة

استيقظ سكان الغوطة الشرقية ومعظمية الشام بالغوطة الغربية يوم 21 أغسطس/آب 2013، على مجزرة غير مسبوقه في تاريخهم، استعملت فيها صواريخ تحمل مواد كيميائية، قضى على إثرها أكثر من 1450 شخصا أغلبهم من الأطفال.

احببنا ان نبدأ المحاضرة بهذه المقدمة التي آلمت جميع القلوب قبل ثلاث سنين، حيث لا يزال صدى صرخات الاطفال السوريين يتردد بمسامع أهالي الغوطة الذي كانوا شهداء على المجزرة الصامتة، المجزرة التي مات ضحاياها بصمت و من دون دماء بسبب استنشاقهم لذلك الغاز المسمى بغاز الاعصاب Nerve agent.

فعاؤنا لأنفسنا التي نسيت هذه المجزرة و التي اعتادت ان ترى مثل هذه المجزرة و كأنه حدث روتيني

.و من ثم عزاؤنا لأهل سوريا، سائلين الله المولى عز و جل ان يرحم شهداء سوريا و أن يصبر أهاليهم و أن يفرج كربتهم عاجلا غير آجل فإنه على كل شيء قدير.

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

✧ What are the mechanism involved in injuries?

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

✧ What are the determinants of the degree of injury?

- ✓ Concentration (e.g. It differs when you swim in a pool mixed with chemical compound, or when someone throw fresh chemical compound directly on your body)
- ✓ Duration of exposure.
- ✓ Anatomically weaker body parts (areas of thin skin).
Skin that is particularly thin or broken can contribute to more severe injury.

✧ What are the differences between Acidic & Alkalic injuries?

- Upon interaction with skin:
 - ✓ **Acids:** Cause protein denaturation & **coagulative necrosis**, and then **Eschar formation.**
 - ✓ **Alkali:** **Saponification** and **liquefactive** necrosis of body fat.
- ALKALI IS MORE DANGEROUS**

✧ Coping with Hazmat incidents:

- ✓ Securing Scene, implementation of site plan & evacuation.
- ✓ Treatment which **starts with decontamination.**

✧ General Management Principals:

- ✓ Remove from hostile environment.
- ✓ Remove cloths.
- ✓ Decontaminate (wounds, then eyes, then mucus membranes, then skin, then hair).
- ✓ Goal is to **normalize skin PH.**
- ✓ Hydrotherapy. (Treatment with water)

Eschar limits the depth to which the acid can penetrate. Despite that **acidic burns** can, nonetheless, produce profound burns. **alkali burns** tend to penetrate deeper into the tissues, which results in significant tissue damage.

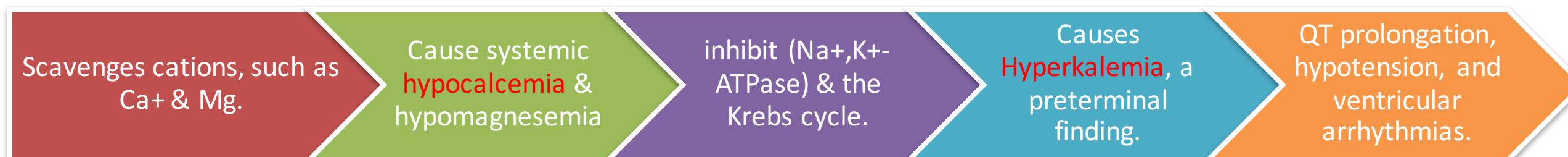


Hydrofluoric Acid

- 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:



○ Routes of exposure:

Types of Exposure	Inhalational	Gastrointestinal	Ocular	Dermal
Occurrence	Rare	Rare	_____	Most common
Symptoms	Inhalation and skin exposure to 70% HF can result in <u>pulmonary edema & death within 2 hours.</u>	leads to life threatening toxicity.	-Severe burn with <u>penetration and necrosis of the structures throughout the anterior chamber.</u> -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.
Management	<ul style="list-style-type: none"> ✓ Irrigation for 15 to 30 minutes. ✓ <u>Blister removal.</u> ✓ Detoxification Locally, Infiltration or Intra-arterial infusion of Ca. Gluconate. 			

Hydrocarbon

- Found in fuels, solvents, paints, paint and spot removers, dry cleaning solutions, lamp oil, rubber cement, and lubricants.
- Classified into:
 - **Aromatic:** Carbon arranged in a ring.
 - **Aliphatic:** Carbon arranged in a linear or branched chain

✧ Mechanism of action:

- ✓ Lungs (aspirations) are the most common organ affected
- ✓ Systemic toxicity from dermal exposure is rare. (by logic, if you pour fuel on a someone's body, he will not develop systemic abnormalities)
- ✓ Ingestion of hydrocarbons can result in aspiration and systemic toxicity (this one seems logically 😊)
- ✓ Perioral or perinasal dermatitis with pyoderma. This so-called "huffer's rash" pic
- ✓ Substances with **high** volatility, **low** viscosity, and **low** surface tension are **the most toxic**. (it's an important point for Qs, such as: What are the characteristics of a high toxicity compound ?)

✧ Management:

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



CHEMICAL TERRORISM

1. Nerve agents.
2. Vesicants (Blistering agents): used in World War I and World War II
3. Choking agents
4. Cyanide and related toxins.

✧ Nerve agent:

- The primary mechanism of action of the nerve agents to prevent acetylcholinesterase from hydrolyzing Ach (Muscarinic effect)
- Effects of **Muscarinic Receptors**:
 - ✓ **DUMBELS** (diarrhea, urination, miosis, bronchoconstriction or bronchorrhea, emesis, lacrimation, and salivation). OR
 - ✓ **SLUDGE** (salivation, lacrimation, urination, defecation, and gastrointestinal emesis)
- Effects of **Nicotinic Receptors**:
 - ✓ Muscle fasciculations and weakness
- Primary clinical toxic effects are **respiratory**

Management:

- ✓ Decontamination with large-volume, low-pressure irrigation with water.
- ✓ Maintaining an airway and restoring adequate oxygenation and ventilation.
- ✓ Anti-muscarinic (**Atropine**), pralidoxime. (the muscarinic Antidote is **Atropine**. However, you have to MORE and MORE Atropine)
- ✓ Benzodiazepines for seizures.

CLASS	EXAMPLE*	TREATMENT
Nerve agents	Tabun (GA) Sarin (GB) Soman (GD) Cyclosarin (GF) VX	Atropine and pralidoxime
Vesicants	➔ Mustard agents Mustard, sulfur mustard (H) Distilled mustard, sulfur mustard (HD) Nitrogen mustard (HN1, HN2, HN3) Organic arsenical agents (e.g., lewisite; L) Halogenated oxime agents (e.g., phosgene oxime; CX)	Hydrotherapy Moist dressing on blisters Supportive care
Choking agents	➔ Phosgene (CG) Chlorine (CL) Military smoke (HC) Chloropicrin (PS)	Supportive care
Cyanide agents	Hydrogen cyanide	Cyanide kit Amyl nitrite Sodium nitrite Sodium thiosulfate Hydroxocobalamin



CHEMICAL TERRORISM

✧ Cyanide:

Used for	<ul style="list-style-type: none">• Cyanide salts and hydrocyanic acid are commonly used for metal cleaning, precious metal extraction, photographic processes, electroplating, laboratory assays, and jewelry cleaning, and Combustion of Plastic containing compounds.• It's a poisoning in fire victims
Mechanism of action	<ul style="list-style-type: none">• Cellular toxin.• Binds to both Fe³⁺ and cobalt.• Inhibits oxidative phosphorylation.• Cellular hypoxia and death.
Clinical picture	<ul style="list-style-type: none">• Sudden cardiovascular collapse.• Coma.• Profound metabolic acidosis. (lactic acid increased more than 10)• A characteristic odour of bitter almonds is frequently discussed but only rarely clinically noted.
Laboratory testing	<ul style="list-style-type: none">• Levels are confirmatory. (there are lab tests for Cyanide, but it takes time)• lactic acid increased more than 10• cellular hypoxia in spite of normal SpO₂%
Management	<ul style="list-style-type: none">• Decontamination• Personal Protective Equipment PPE• ABCD• Antiarrhythmics• Antidotes (there are two types of Cyanide antidotes):<ol style="list-style-type: none">1. Cyanide antidote kit (Amyl nitrite, sodium nitrite, and sodium thiosulfate)<ul style="list-style-type: none">✓ Amyl nitrite and Sodium nitrite: induces methemoglobinemia → cyanide binds to metho globin forming Cyanomethoglobin (Nontoxic)✓ sodium thiosulfate: enhances transulfuration of hydrogen cyanide to thiocyanate (Nontoxic) , which is renally excreted2. In December 2006, the Food and Drug Administration approved hydroxocobalamin for treatment of cyanide intoxication, which branded as Cyanokit antidote• 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:

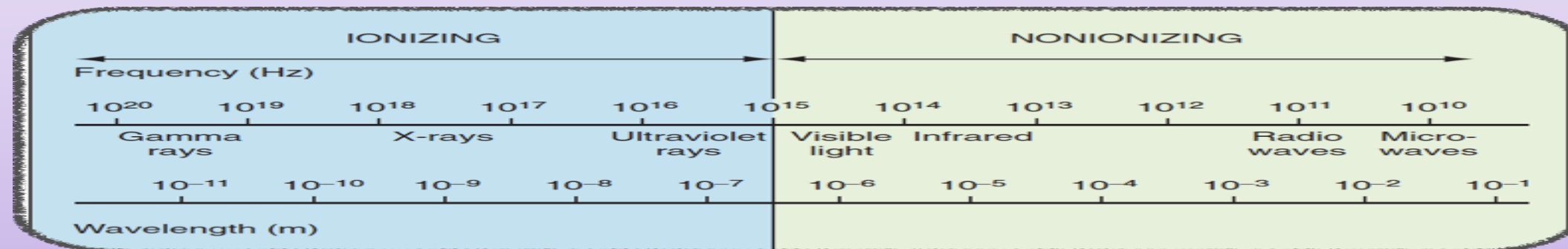
- The spontaneous transformation of an unstable isotope to a stable one, and it may involve the release of ionizing radiation

Nonionizing radiation

- The primary adverse effects of nonionizing radiation are related to **local heat production**.

Ionizing radiation

- Directly cause **cell death** or **damages the DNA**
- Ionizing radiation is emitted in the form of **alpha and beta particles, gamma rays, and x-rays**.



Irradiation (is the process by which an object is exposed to radiation)

- Object that is irradiated does not become radioactive

Contamination

- Radioactive contamination is a radioactive particulate matter (alpha and beta particles) on an exposed surface

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.

Incorporation

- Incorporation occurs when a radioactive material is ingested, inhaled, or absorbed through an open wound

Radiation exposure

✧ 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.
- The early indicator for a significant radiation exposure is **the absolute decreased lymphocyte count**, which can occur within 48 hours after exposure table1
- The LD50 or median lethal whole-body dose (the dose that is lethal for 50% of test population), assuming proper medical care, is estimated to be **approximately 4.5 Gy (Gray)**
- **Management:**
 - ✓ Reduce Exposure.(time, distance, and shielding)
 - ✓ Decontamination
 - ✓ Effective ED (Emergency Department) preparedness (Involve radiation control officer).
 - ✓ Geiger-Mueller instrument for monitoring the environment. Pic
 - ✓ ABCD's & Supportive measures.
 - ✓ Chelating agents for Internal contamination. Table2



MINIMAL 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

1

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)

2

➤ You have to know that, when **the lymphocytes count is lower than 500**, the injury will be very severe and the prognosis will be poor.

MCQs

Q1: Which of the following occur upon interaction of acids with the skin?

- A- Fat necrosis
- B- Coagulative necrosis
- C- Liquefactive necrosis
- D- Saponification

Q2: Which of the following is NOT a determinant of the degree of injury?

- A- Concentration
- B- Duration
- C- Route
- D- Weaker areas of the body

Q3: initiation of decontamination should start at which of the following?

- A- Eyes
- B- Hair
- C- Skin
- D- Wound

Q4: Hydrofluoric acid is considered similar to alkaline in which of the following?

- A- It causes eschar formation
- B- Cause saponification
- C- Cause liquefactive necrosis
- D- Have the same chemical features

Q5: Which of the following electrolyte imbalances result from Hydrofluoric acid exposure?

- A- Hypercalcemia + Hypomagnesaemia + hyperkalemia
- B- Hypocalcemia + hyperkalemia + hypermagnesaemia
- C- Hypercalcemia + hyperkalemia + Hypomagnesaemia
- D- Hypocalcemia + hyperkalemia + Hypomagnesaemia

Q6: Which of the following is the most common way of exposure to hydrofluoric acid?

- A- Ocular exposure
- B- Inhalation
- C- Dermal exposure
- D- GI

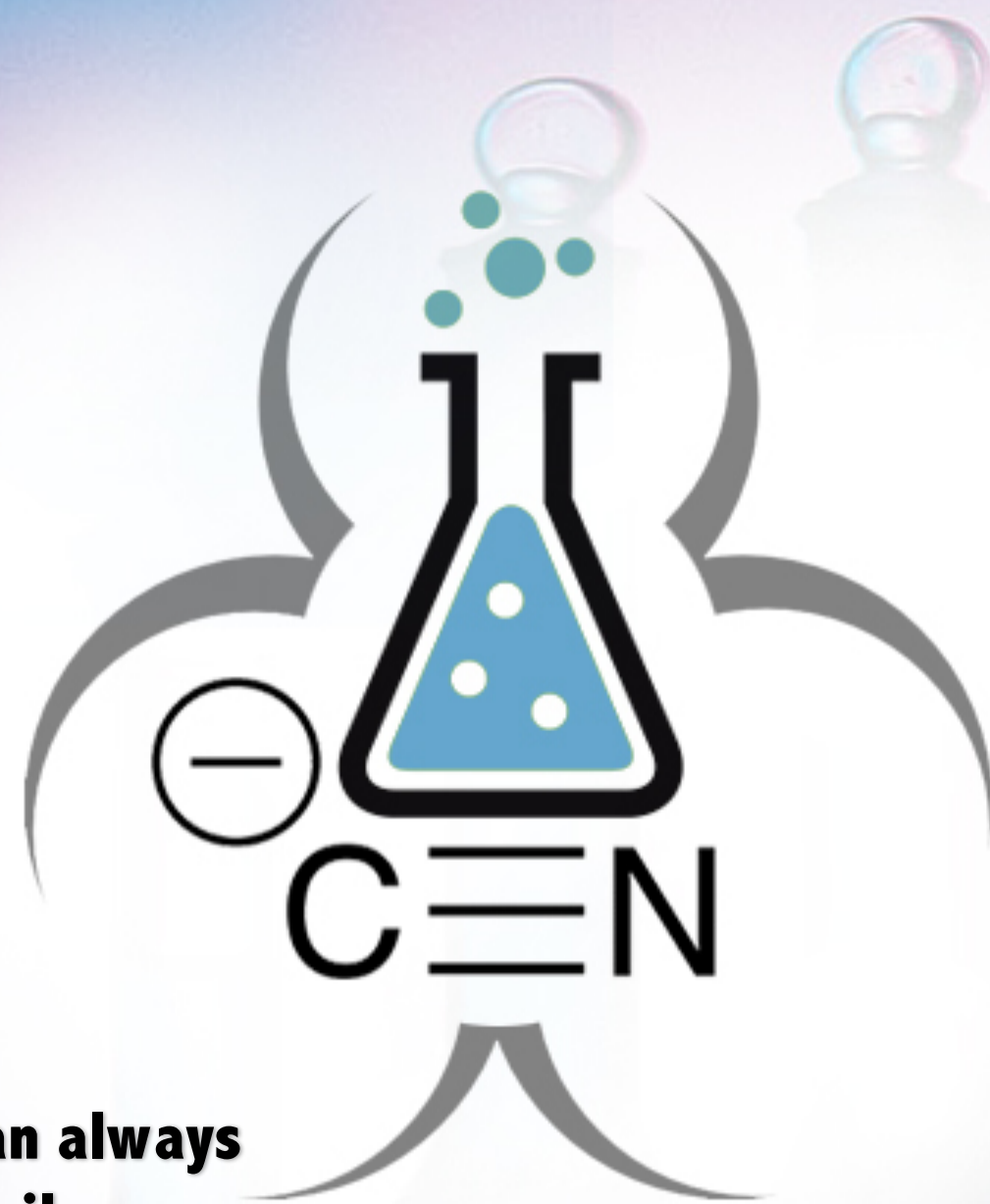
Q7: Which of the following is a feature of highly toxic hydrocarbon?

- A- High viscosity
- B- Low volatility
- C- High PH
- D- Low surface tension

Q8: Which of the following is an indicator of poor prognosis in acute radiation syndrome?

- A- WBC count less than 5000
- B- Lymphocyte count between 500-1000
- C- Approximated absorbed dose of 2-3.9 Gy
- D- Lymphocyte count less than 500

ANSWERS: 1-B 2-C 3- D 4- C 5-D 6- B 7-C 8- D



**If you have any questions You can always
contact us at : forensic433@gmail.com**

Done By: Omar Aldhasee

Revised By: Malak A. ALMutairi