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TABLE OF CONTENTS

1. Learning Outcomes

After studying this module, you shall be able to know about-

- The significance of Corrosive Substances and related Poisoning
- The Classification of Corrosive Poisons and some notable illustrations
- The Forensic importance of Corrosive poisoning

2. Introduction

"Corrosive substance", plain and simply means a substance which may cause something weak and damaged while in term of chemistry language they are the substance that causes perceptible discoloration, decay, or irreversible changes, in living tissue at the site of contact within few hours. For the similar effect on non-living material, the term 'corroding' may as an alternative be used. In the field of Toxicology, a "toxin" largely refers to toxic substances that are produced by biological systems such as plants, animals, fungi, or bacteria, whereas, the term "toxicant" is used in speaking of toxic substances that are synthesized by human made activities. Classification of toxic agents on the basis of their biochemical mechanisms of action is usually more explanatory than classification by general terms such as irritants and corrosives. Corrosives are the poison that fixes, destroys and causes erosion of the surface coming in its contact. This group consists of strong Acids and alkalis. Corrosive substance causes destruction of tissue at the site of application. In dilute solution many corrosives simply have an irritant effect, but irritants may corrode at certain sites. According to this definition the effects of a corrosive should be restricted to its local action, but some of them produce grave effects from absorption, so the classification is an unsteady one. Some organic Acids like Oxalic and Carbolic Acid act as corrosives in concentrated form as do Carbonates of Sodium and Potassium. Certain metallic salts for example Sodium Chloride, Potassium Cyanide, Ferric Chloride, Chromates and Bi-chromates of alkalis also act as corrosives. The term caustic is often inaccurately presumed to represent an Alkali, while actually it has a much comprehensive meaning and refers to any substance which is corrosive and burning in nature. Obviously, this would include separately from alkalis, the more important group comprising inorganic and organic Acids. The strong solutions of alkalis act as corrosives but in dilute form, they act as irritants. Concentrated corrosive alkalis are more dangerous than Acids.

3. Forensic Issues

Corrosive poisoning is a common, as exposure to corrosive agents remains to be a leading toxicological source of injury for children and adults. An average home contains a dozen different cleaning products and most of them are of corrosive in chemical nature. These account for a large number of accidental and deliberate poisonings. While most cases are suicidal, a few accidents occur, apparently remaining to the observance of small quantities of disinfectant in old medicine or liquor bottles. Accidents are consistently distributed between men and women, but the latter preponderate in the use of this method of self-destruction. Corrosive poisoning from swallowed mineral Acid is much more common than that from caustic alkalis, and the majority of cases are due to suicidal attempts. Most of the accidents happen to men and Hydrochloric Acid is by far the commonest agent. The cause for this is incomprehensible, but Hydrochloric Acid may be purchased from the pharmacist and kept in old bottles prior to use as a cleaning agent for glazed surfaces. Hydrochloric and Sulphuric Acids are widely used in industrial processes, and some may be obtained from the factory for private purposes such as soldering fluid. Oxalic Acid is less common as a corrosive agent than it used to be, but a few cases of poisoning still occur. The usual source is the purchase from the pharmacist for the use as a cleaning agent. The introduction of cleaning agents may have made this poison more readily accessible. Formalin, another common suicide agent, may be obtained easily for use as a hardening agent in photography, and has been used as a disinfectant for soft furnishings and other un-washable articles. It is also used in the plastics and cellulose industries. These are highly active irritants which produce both inflammation and ulceration of tissues. It is interesting to note that while generally speaking, the lower the pH of an Acid the higher is its corrosive effect, it is not the pH alone which is the element of severity. For example, lemon juice which has a very low pH is not corrosive in nature at all. More important determinants include molarity, concentration, and complex affinity for hydroxyl ions. Ingestion of Acid causes more damage to the stomach than the oesophagus because the squamous epithelium of the latter is more resistant to Acids, while it is just the opposite in the case of alkali ingestion where the columnar epithelium of the stomach is more resistant. However, the current concept is that the minimal oesophageal damage in Acid ingestion is more probably because of rapid oesophageal transit and limited penetrating ability, rather than from any special protective properties of the columnar epithelium. Acid burns of the stomach most commonly involve the antrum and pylorus. All caustics are highly injurious locally and produce burns of varying severity and intensity.

4. Classification of Corrosive Poisons

Corrosive toxic agents are classified in a variety of ways, depending on the interests and needs of the classifier. However, on the basis of their chemical nature they can be classified as:

(1) Inorganic Acids **(2) Organic Acids** **(3) Alkalis**

4.1 Inorganic (Acids) Corrosive Poisons

4.1.1 Sulphuric Acid

It is also known as Oil of vitriol or Oleum or Battery Acid. Sulphuric Acid is a heavy, oily, colourless, odourless, non-fuming liquid. It is hygroscopic, i.e. it has great affinity for water with which it reacts violently, providing off intense heat. Sulphuric Acid is mainly used in two forms, one is the commercial concentrated Sulphuric Acid, which is usually a 93–98% solution in water and the other one is the Fuming Sulphuric Acid, which is a solution of Sulphur Trioxide in Sulphuric Acid. Pure Sulphuric Acid is colourless with no fumes and it chars and blackens the skin. Commercial Sulphuric Acid is dark or brown in colour due to the addition of impurities like Lead Sulphate, Arsenic or Nitric Acid. Nordhausen Acid or $H_2S_2O_7$ (Pyrosulphuric Acid) is stronger, brown, oily and fuming liquid used in the manufacture of Indigo. Sulphuric Acid is chiefly used for preparing chlorine, for dissolving metal, for cleansing drains, for medicinal purposes, and to remove fur from kettles. Accidental poisoning may arise from mistaken identity since Sulphuric Acid resembles Glycerine and Castor Oil. Mostly, it is employed for suicidal purposes due to its easy availability. However, Sulphuric Acid is a rare choice for homicide. The usual fatal dose is about 20 to 30 ml of concentrate Sulphuric Acid. However, deaths have been reported with ingestion of as little as 3.5 ml.

4.1.2 Nitric Acid

Nitric Acid is also known as Aqua fortis, Azotic Acid, Engraver's Acid, Hydrogen nitrate. Nitric Acid is a colourless or yellowish fuming liquid with an unpleasant and penetrating odour. It is essentially a solution of Nitrogen Dioxide (NO_2) in water and is available commercially in several forms. It is a powerful oxidizing agent which can dissolve all metals except Gold and Platinum. It is able to destroy organic matters with formation of Xanthoproteic Acid that imparts deep yellow colour to the affected tissues. Workers in the glassblowing, engraving and electroplating, underground blasting operations, farming, silage, fertilisers, welding, fire fighting, and industrial chemistry professions may be exposed to nitrogen oxides or Nitric Acid. Forensically, cases of Nitric Acid poisoning reported mostly are of accidental or suicidal in nature and rarely homicidal. The Fatal Dose is about 20 to 30 ml while the approximate fatal period could be 12-24 hours.

4.1.3 Hydrochloric Acid

Hydrochloric Acid, also known as Muriatic Acid or Spirit of Salts, is a colourless, fuming liquid which may acquire a yellowish tinge on exposure to air. It is actually Hydrogen Chloride in water. Pure Hydrochloric Acid is colourless and fuming liquid with strong pungent irritating odour. The strong solution gives fumes even at ordinary air and temperatures. When the solution is ingested, its liberated gas is also inhaled. It is a natural constituent of the fluids of stomach and bowel. It is used, as a Bleaching agent, in Dyeing industry, Metal refinery, in Flux for soldering, as Metal cleaner, drain cleaner, as Laboratory reagent. Muriatic Acid is the solution of Hydrochloric Acid gas in water having yellow colour and fumes strongly in damp air. It is used commercially and is less destructive than Sulphuric and Nitric Acids. Hydrochloric Acid does not stain the skin and mucous membrane but stains dark clothes reddish brown. Since it is volatile, it readily affects the Respiratory tract mucosa. The fatal dose for Nitric Acid is about 15 – 20 ml. and fatal period may vary from 18 – 24 hrs. Mostly suicidal poisoning is common related with Hydrochloric Acid but there are a few cases of accidental poisoning reported as well. It is very rarely homicidal. However, it is though rarely injected in to the vagina to produce abortion and it causes atresia of the vagina. It is used for erasing writing in the attempts of forgery.

4.2 Organic Corrosive Poisons

4.2.1 Carbolic Acid

This is the hydroxy benzene obtained from coal tar oil by fractional distillation. Pure Carbolic Acid has colourless, prismatic needle shaped crystals with burning sweetish taste. It turns pink and liquefies when exposed to air having a carbolic smell. Carbolic Acid is slightly soluble in water and easily soluble in Glycerine, Ethers and Alcohols. Carbolic Acid and its derivatives are generally used as disinfectants, antiseptics, germicides, caustics and preservatives kept in cabinets and almirahs. Lysol is as dangerous as Phenol, which is used in the manufacture of explosives, fertilizers, textile, rubber, plastics, dyes, drugs and in preservations of vaccines etc. Poisoning by Carbolic Acid is known as Carbolism. The fatal dose of Carbolic Acid is 10-15 gm and the fatal period is about 3-4 hours

4.2.2 Formic Acid

Formic Acid is also known as Aminic Acid, Formylic Acid, Hydrogen carboxylic Acid, or Methanoic Acid. It is a colourless liquid with a pungent, penetrating odour. Formic Acid is a natural constituent of some fruits like apples, pears, plums, apricots, nuts, and dairy products. Some wines may contain Formic Acid. Formic Acid is an important toxic metabolite produced in methanol poisoning, since it is metabolised in the body to produce formaldehyde and formic Acid. Formic Acid is readily absorbed from the Gastro Intestinal tract. Accidental and suicidal poisoning with Formic Acid is relatively common in those areas where the chemical is easily available.

4.2.3 Acetic Acid

It is a colourless, volatile liquid with a characteristic pungent odour. At 10°C to 15°C, the Acid occurs in crystalline form such as Glacial Acetic Acid. Acetic Acid is also known as Ethanoic Acid, Ethylic Acid, Methane carboxylic Acid, or Pyroligenous Acid. About 50 to 100 ml of concentrate Acetic Acid would be fatal for an individual. In concentrated form, Acetic Acid is a corrosive although mild, while in dilute form it acts as an irritant.

Systemic absorption leads to haemolysis, haemoglobinuria, and kidney failure. Most cases of poisoning due to Acetic Acid are accidental. There are however occasional reported cases of suicide.

4.2.4 Oxalic Acid

Oxalic Acid is colourless, transparent and prismatic crystals resembling Magnesium Sulphate. It is an organic corrosive Acid and prepared from sugar by oxidation with Nitric Acid or by heating Sodium or Potassium Formate. It is the simplest dicarboxylic acid. It is a potentially toxic chemical which is synthesised commercially and is also naturally present as a salt in many plants. Oxalic Acid is a relatively strong Acid, and forms a white, dihydrate precipitate. In solid or concentrated form or in large quantities, it acts as a corrosive but in weaker solutions, it acts as an irritant and this is more substantial in the nervous system. When applied to the wound, it acts as a poison. The Fatal dose is reported to be 15-20 gm and the fatal period is 1- 2 hours.

4.3 Alkalis and Other Caustics

Alkalis commonly encountered in poisoning include Ammonia (usually in the form of Ammonium Hydroxide), carbonates of sodium and potassium, and hydroxides of sodium, potassium, and calcium. Sodium Hypochlorite is also increasingly being implicated. Most of these occur as white powders or colourless solutions. The strong solutions of alkalis act as corrosives but in dilute form, they act as irritants. Concentrated corrosive alkalis are more dangerous than Acids. Some alkaline corrosives with their fatal doses are the following:

- Potassium hydroxide (Caustic Potash) - 5 gm.
- Sodium hydroxide - 5 gm.
- Potassium carbonate (Caustic Soda) - 18 gm.
- Sodium carbonate (Washing soda) - 30gm.
- Ammonia - 30 gm.

Lye is a mixture of Caustic Soda and Sodium Bicarbonate that is used for cleaning purposes. Caustic Potash and Caustic Soda is extensively used for commercial purposes as cleansing agents in washing powders and pipeline cleaners. They are also used as ointments in medicines.

The caustic action results from the absorption of water from the tissues as they precipitate proteins. They combined with proteins to form proteinases and with fats to form soaps, thus produce soft, necrotic effect deeply penetrating areas on contact with tissues. Locally, alkalis produce liquefaction necrosis which results in extensive penetrating damage because of saponification of fats and solubilisation of proteins. Production of ulcers is common which may persist for several weeks. Oesophagus is more severely affected than the stomach in contrast to Acids

5. Summary

- Corrosives are the poison that fixes, destroys and causes erosion of the surface coming in its contact. Some organic acids like Oxalic and Carbolic Acid act as corrosives in concentrated form as do carbonates of sodium and potassium.

- Carbolic Acid has a great penetrating power as it coagulates protein but does not occur in chemical combination with them. When applied to the skin, it produces burning sensation, numbness, and anaesthesia due to its action on the nerve endings.

- Oxalic Acid and Oxalate have a rapid double action-immediate corrosion and subsequent depression of the heart and nervous system. A concentrated solution has similar effects to the inorganic Acids, giving rise to pain, vomiting of altered blood, suffocation, shock, and collapse.

- Commercial topical solution of hydrogen peroxide is a clear, colourless liquid with a faint ozone-like odour and bitter taste. It deteriorates on standing, repeated agitation, or exposure to light.

- Potassium Permanganate is an irritant, and in highly concentrated form it acts as a corrosive. It also exhibits systemic toxicity.

- Vitriolage is throwing of strong Sulphuric Acid, concentrated mineral acid, corrosive alkalis, Carbolic Acid over the face or body of the victim for the purpose of disfiguring the face, destroying the vision for causing injury on the body or even destroying the clothing of the victim.

- Sections 326 - A and 326 - B of the Criminal Law (Amendment) Ordinance, 2013 refers to the penalties in the cases of Acid Attacks.