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ARSENIC – AN INORGANIC METALLIC IRRITATIVE POISON & IT'S MEDICO-LEGAL ASPECTS

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ABSTRACT

It is the commonest source of acute heavy metal poisoning and is second only to lead in the incidence of chronic toxicity. Arsenic is highly toxic in its inorganic form. Contaminated water used for drinking, food preparation and irrigation of food crops poses the greatest threat to public health from arsenic. It has toxic effects in various organs in human body. Arsenic increases the risk of cancer. Exposure is related to skin, lung, liver, and kidney cancer among others. For medico legal issues arsenic is also very important.

KEYWORDS: Arsenic, Metal, Poison, Public health, Food, Medico-legal aspects.

INTRODUCTION

Metallic arsenic is not poisonous as it is not absorbed from the GIT (Gastrointestinal tract). Inorganic arsenic compound are poisonous. It is a normal constituent of all animal tissue, in minute amount.[1] Arsenic poisoning is a medical condition that occurs due to elevated levels of arsenic in the body Arsenic is a chemical element with symbol As, atomic number 33. Arsenic poisoning can cause major health complications and death if it is not treated, so precautions exist to protect those who are at risk. Study of Arsenic is also important for the purpose of medico-legal importants. Arsenic has been used since ancient times as a medicinal agent, a homicidal and more recently in deliberate and unintentional self-poisoning.[2]

TOXIC COMPOUNDS[3,4]

1. Arsenic oxide or Arsenic trioxide (Sankhya , White arsenic) – Most toxic from arsenic. It has no taste or smell and sparingly soluble in water. It is used in fruit sprays, sheep-dips, insecticides, rat poisons, wallpapers, artificial flowers etc.

2. Copper arsenite (Scheele's green) and Copper acetoarsenile (Paris green) – It is used as coloring agent for substances including confectionary.

3. Sodium arsenite - It is white or grayish powder. It is used in insecticides, wood preservative etc.

4. Arsenic trisulfide (Hartal) - Yellow orpiment and red realgar or Arsenic disulfide are used as depilatory, coloring pigment and in flypaper.

5. Arseniuretted hydrogen or Arsine - It is a colorless gas with garlic like odour.used in lead plating, soldering and electronic components.

6. Arsenic pentoxide or arsenic acid – It is a white powder, used in manufacture of coloured glass, insecticide etc.

7. Trimethyl arsine or gasio gas - It is colourless gas present in sewage.

SOURCES OF ARSENIC EXPOSURE[5]

1. Rocks and soil
2. Hot spring mineral water
3. Drinking water
4. Sea water
5. Vegetable, fruit and grains
6. Sea foods
7. Industrial sources

MODE OF ACTION[6]

Arsenic interferes with cellular respiration by uncoupling mitochondrial oxidative phosphorylation by combining with the sulfydryl groups of mitochondrial enzymes, especially pyruvate dehydrogenase and certain phosphatases. Consequently conversion of pyruvate to acetyl Co A is decreased. It inhibits cellular glucose uptake gluconeogenesis of acetyl Co A. Locally it causes irritation of mucous membranes and remotely depression of nervous system.

ABSORPTION AND EXCRETION[7]

It is absorbed through all portals of entry and re- distributed to liver, lungs, intestinal wall and spleen. It is present in almost all tissues and found in the greatest quantity in the liver followed by kidney and spleen. In cases where the patient survives it is found in the muscles (for months), bones, hair, nails and skin (for years).

It is excreted mainly through kidney (urine), but some part through faeces, bile, sweat, milk, nails and hairs. Arsenic is secreted into the stomach and intestine after absorption even when given by routes other than mouth.

FATAL DOSE

- 120-200mg of Arsenic trioxide (adults)
- 2mg/kg (children)

FATAL PERIOD

-In narcotic form – 2 to 3 hours[8]

-In gastrointestinal form – 12-48 hours.

SIGNS AND SYMPTOMS

1. ACUTE POISONING

2. CHRONIC POISONING

1. ACUTE POISONING[9]

Symptoms usually appear by 10 minutes to 1 hour after ingestion but may be delayed, if arsenic is taken with food. The principal manifestation of acute arsenic poisoning are acute gastrointestinal disturbances .When a large dose of arsenic is taken and poison is quickly absorbed, the symptoms of gastroenteritis may be absent , and symptoms of narcotic poisoning , such as vertigo, headache, spasm, followed by stupor and vascular collapse may be present. Death occurs within 2-3 hours.

GIT – Sweetish metallic taste, abdominal pain, garlicky breath, dysphagea, vomiting, bloody or rice water diarrhea, pain and irritation about the anus, intense thirst, burning in mouth & throat.

RENAL - Oliguria, uraemia, albuminuria, red cells, micturition.

CVS- Hypotension, pulmonary edema, circulatory collapse, cardiac arrhythmias.

HEPATIC - Fatty degeneration.

MUSCULAR SYSTEM- Pain in limbs and weakness.

CNS - Hyper pyrexia, convulsions, vertigo, general paralysis, coma.

SKIN - Hair loss, transverse bands of opacity in nails.

2. CHRONIC POISONING[10]

Chronic arsenic poisoning may occur due to

- Accidental ingestion of small doses repeatedly by those working with metal.

- Intake of food/drinks in which there are traces of arsenic.
- Recovery from an acute poisoning.

Some people take arsenic daily as a tonic or as an aphrodisiac and they acquire tolerance to 250-300mg or more in one dose such people are known as arsenophagagitis.

Symptoms are misleading and appear in four stages

1. First stage – GIT disturbance

-Anorexia
-Malaise
-Fever
-Salivation
-Colicky pain
- Constipation
-Vomiting
-Gums are red and soft
-Tongue is coated with thin white silvery fur.

2. Second stage – Catarrhal changes

-Sense of fullness in head
-Running nose
-Conjunctivitis
-Lacrimation
-Cough
-Hoarseness of voice.

3. Third stage – skin lesion predominant

-Erythematous eruption
-Urticarial rashes
-Hair fall
-Eczematous lesions
-Rain drop pigmentation of skin
-Nails – brittle showing linear pigmentation
-Dry throat with itching
-Hepatomegaly
-Kidney damage may be seen.

4. Fourth stage – sensory & muscular atrophy predominance

-Tingling and numbness of extremities
-Marked tenderness and cramps of muscles
-Knee jerk lost
-Bone marrow depression with aplastic anaemia.
-Muscular weakness, ataxia, wrist drop & foot drop
-Tremors, generalized emaciation, delusion, dysuria
-Death may occur due to heart failure**.**

Differential diagnosis

Acute Arsenic poisoning has to be differentiated from Cholera

S.N.	CLINICAL FEATURES	ARSENIC POISONING	CHOLERA POISONING
1.	Pain in throat	Present before vomiting	Absent
2.	Voice	Normal	Rough and whistling
3.	Conjunctivae	Inflamed	Normal
4.	Vomiting matter	Contains mucus, bile and blood spots	Watery
5.	Purging	Occurs after vomiting	Before vomiting
6.	Stools	High coloured, bloody with foetid odour, tenesmus	Characteristic rice water stool and discharge is almost continuous
7.	Laboratory investigation	- Radiopaque shadow (X –ray abdomen) seen in arsenic	- Not so

		trioxide - Urinary coproporphyrin test- positive - Stool chemical analysis- Arsenic detected	- Negative - Cholera vibrio detected
8.	Circumstantial evidence	Poisoning may be present in an individual or a family or a group	May occur in sporadic or epidemic form in locality

LABORATORY INVESTIGATIONS

Urine, stool, blood, vomit, hair and nails from patients and in addition, stomach and intestinal contents, bone, liver, bile, and kidney from dead bodies are tested.

Urine: Excretion of > 50 µg/l in 24 h urine is indicative of poisoning.

Blood (serum arsenic> 0.9 µg/dl) , stool. Liver, kidneys, and bones show presence of arsenic.

Hair: Arsenic > 75µg% is suggestive of poisoning.

Nails: Presence of > 100 µg% of Arsenic is suggestive of poisoning.

Radio-opaque sign on abdominal X-ray.

ECG: QRS broadening, QT prolongation, ST depression and T wave flattening.

Marsh, Reinsch and Gutzeit tests are absolete**.**[11]

Marsh test: Granulated zinc with dilute sulphuric acid releases hydrogen which burns with a pale blue flame on applying a light to it. On adding to it suspected mixure of Arsenic, the flambegins to burn with a bluish or greenish- violet or purple tint which also emits a garlic-like odour.

Reinsch test: Drop a strip of bright copper foil in the suspected solution containing pure HCL, boil it for 5-10 minutes. If arsenic is present, the copper foil will be coated steel grey or black.

Gutzeit test: Add to the suspected solution , a piece of chemically pure zinc and few ml of sulphuric or hydrochloric acid containing iodine solution in a test tube and cover its mouth with a piece of filter paper. If arsenic is present, the paper turns yellow.

TREATMENT[12]

1. Prevention of further exposure.
2. Gastric lavage is done repeatedly with large amount of warm water and milk.
3. Demulcents (Ghee, albumen, tea, butter) prevent absorption.
4. Whole bowel irrigation with polyethylene glycol.
5. Antidotes

-BAL (British anti-lewisite or dimercaprol) - 3-5 mg/kg 4 hourly for 2days, 6 hourly foe 1 day and then 12 hourly for 10 days.

-DMSA (Meso- dimercaptosuccinic acid**)** – 10 mg /kg every 8 hourly for 10 days

-DMPS (Dimercapto propanesulfonic acid**)**– 200mg IV 4 hourly

6. Purgatives (castor oil / magnesium sulfate) are given to remove unabsorbed poison from intestine.
7. Glucose saline with sodium bicarbonate is helpful to combat shock and improve alkali reserve.
8. Hemodialysis or exchange transfususion may be done.

POST MORTEM APPEARANCE: -

IN ACUTE ARSENIC POISONING

A.EXTERNAL APPEARANCE

1. The body looks emaciated due to dehydration.

2. Rigor mortis appears early & putrefaction is delayed due to anti-bacterial action.
3. Sunken eyes and skin is cyanosed

B.INTERNAL APPEARANCE

1. GIT

-Inflammation or ulceration in mucous membrane of the mouth, pharynx and oesophagus.

-Stomach shows frequent changes

a. Containing food articles mixed with gritty, sandy particles of arsenic.

b. Mucous membrane: swollen, softened and congested, tinged with blood spots and white particles of arsenic embedded in it, colour varing from brownish – red or bright scarlet.

c. Greater curvature and posterior part of the cardiac end is inflamed.

-Small intestine

a. Flabby containing the large flakes of mucus with a very little faecal matter

b. Mucous membrane; pale, violet coloured, inflamed with submucous haemorrages.

-Large intestine; empty, contracted.

-Caecum and rectum; inflamed, flabby mucous membrane, peritoneum; congested, pink in colour.

2. Liver, Spleen and Kidney

Highly congested, enlarged and may show fatty infiltration and degeneration.

3. Lungs

Congested with sub pleural ecchymoses

4. Heart

Sub endocardial petechial haemorrhage of the ventricle.

5. Brain

Edema with patchy necrosis, haemorrhagic encephalitis, congested meninges.

IN CHRONIC ARSENIC POISONING

EXTERNAL: Emaciation, pigmentation, keratosis, alopecia, white streaks on nails, jaundice, wasting of muscles, and ulceration of nasal septum.

INTERNAL:

Stomach – chronic gastritis, patchy inflammatory redness or focal ulceration.

Small intestine – redish with thickened mucosa.

Liver – hepatomegaly, fatty degeneration, necrosis with non – cirrhotic portal fibrosis

Kidney – tubular necrosis

Heart – myocardial necrosis

Bone marrow - histopathology will show hypoplasia

PRESERVED FOR CHEMICAL ANALYSIS[13]

1. Routine viscera
2. Long bone- femur
3. Scalp hairs
4. Muscles
5. Skin
6. Nails.

MEDICOLEGAL ASPECTS

1. Homicidal poisoning: arsenic is frequently used as an ideal homicidal poison because:

i) Cheap
ii) Colorless
iii) Onset of symptoms is gradual
iv) Symptoms simulate those of cholera
v) Small quantity is required to cause death
vi) Easily obtainable
vii) Can be administered easily with food, drinks, or betel leaf (paan).

Employed

i) As abortifacient, both orally and locally, in the form of paste;
ii) For cattle poisoning

iii)Admixture with food articles and drinks.

2. Accidental poisoning:

i) Improper medical use or admixture with food articles

ii) Mistaken for baking powder, soda, cream of tartar, sugar and salt

iii) Drinking water from a stream or a well having Arsenic mineral deposits

iv) Use of acetarsol pessaries in the vagina

v) Arsenic exposure can be occupational in those working in metal foundry, mining, glass production or in the semiconductor industry.

3. SUICIDAL POISONING: is rare because it causes too much of pain.

DISCUSSION

Arsenic is one of the most toxic elements that can be found easily. Despite their toxic effect, inorganic arsenic bonds occur on earth naturally in small amounts. Levels of arsenic in food are fairly low, as it is not added due to its toxicity. But levels of arsenic in fish and seafood may be high, because fish absorb arsenic from the water they live in. Luckily this is mainly the fairly harmless organic form of arsenic, but fish that contain significant amounts of inorganic arsenic may be a danger to human health. Arsenic exposure may be higher for people that work with arsenic, for people that live in houses that contain conserved wood of any kind and for those who live on farmlands where arsenic-containing pesticides have been applied in the past. Exposure to inorganic arsenic can cause various health effects, such as irritation of the stomach and intestines, decreased production of red and white blood cells, skin changes and lung irritation. It is suggested that the uptake of significant amounts of inorganic arsenic can intensify the chances of cancer development, especially the chances of development of skin cancer, lung cancer, liver cancer and lymphatic cancer. A very high exposure to inorganic arsenic can cause infertility and miscarriages with women, and it can cause skin disturbances, declined resistance to infections, heart disruptions and brain damage with both men and women. Finally, inorganic arsenic can damage DNA.

The arsenic cycle has broadened as a consequence of human interference and due to this, large amounts of Arsenic end up in the environment and in living organisms. Arsenic is mainly emitted by the copper producing industries, but also during lead and zinc production and in agriculture. It cannot be destroyed once it has entered the environment, otherwise it may spread and cause health effects to humans and animals on many locations on earth. Cases of death due to arsenic poisoning can be detected by post-mortem and chemical examinations. In medico-legal aspects Arsenic poison can be homicidal, suicidal, accidental, occupational or unintentional.

CONCLUSION

Arsenic is an inorganic irritant poison and also called as king of poison. Arsenic is considered a top environmental chemical of human health because it has been linked to adverse health effects including cancer, diabetes, cardiovascular diseases, and reproductive and developmental problems. Millions of people around world are exposed to Arsenic at concentration much higher than the guideline value and therefore the public health priority should be reduced exposure for these people. Arsenic

poisoning death is generally caused by homicidal and accidental & suicide is rarely seen.

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Figure 1.Copper arsenite

Figure 2. Sodium arsenite

Figure 3 Arsenic trisulfide

Figure 4. Arsenic pentoxide