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Review Article

A REVIEW ON ARSENIC POISONING AND ITS POST-MORTEM FINDINGS

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ABSTRACT

Arsenic is a grey substance, which is insoluble in water and therefore cannot be absorbed from the alimentary canal. Arsenic is absorbed through all routes mainly by skin, inhalation and GIT mucosa. Arsenic causes toxicity by combining with sulphydryl enzymes and thus interfering with cell metabolism. Locally it causes irritation of the mucous membranes and remotely depression of the nervous system. Arsenic poisoning can be homicidal, suicidal, accidental, occupational, environmental, iatrogenic or un-iatrogenic. The character of post-mortem appearances depends very largely upon the quantity taken and period which has elapsed before death. Externally the body presents dehydrated, cyanosed, sunken eyeballs jaundiced in post-mortem findings. Rigor mortis lasts longer than usual. Internally red velvet stomach, petechial hemorrhages under the endocardium of the left ventricle, patchy fatty degenerative changes with jaundice in liver, rain drop skin pigmentation and mee's line in nails findings seen in post-mortem.

KEYWORDS: Arsenic, Post-mortem, Medico-legal, Poisoning, Toxicity.

INTRODUCTION

Arsenic being such a common poison is called king of poisons[1]. Arsenic is grey substance and metallic arsenic is not poisonous as it is insoluble in water and is non-absorbable from the alimentary canal. However, it becomes poisonous when it oxides if exposed to air[2]. Arsenic compounds such as orpiment, realgar, white arsenic etc used in as pigments in the field of arts and in tanning to remove hair, rodenticides, fungicides, printing on white clothes, used as coloring agents for toys, wall papers, artificial flowers etc. Frequently used arsenic in Ayurvedic and Unani medicines for the treatment of fever, rheumatism, skin diseases, syphilis and impotence etc[3]. Arsenic and its compounds are well absorbed from skin, mucous membrane, GIT, respiratory tract which is responsible for arsenic poisoning[4]. Arsenic causes toxicity by combining with sulphydryl enzymes and thus interfering with cell metabolism. Locally it causes irritation of the mucous membranes and remotely depression of the nervous system [5].

Arsenic

- Symbol - As
- Atomic number - 33
- Atomic weight- 74.921
- Phase- solid
- Density- 5.727
- Sublimation point- 615^0 C
- Crystal structure- Trigonal

Word Origin: Arsenic was first mentioned by Albertus Magnus in 1250. The word arsenic was taken from the *Syriac* word "*Zarniqa*" and the *Persian* word "*Zarnikh*" that means Yellow orpiment. It is also related to the similar Greek word "*Arsenikon*" that means masculine or potent. The word was adopted in latin arsenicum and old French arsenic, from the English word arsenic is derived. Arsenic sulfides (orpiment, realgar) and oxides have been known and used since ancient time. Zosimos (crica 300 AD) describes roasting sandarch realgar to obtain cloud of arsenic (arsenious oxide) which he then reduces to metallic arsenic[6].

AIMS AND OBJECTIVES

1) To explain Arsenic acute and chronic poison.
2) To explain post-mortem findings of arsenic poisoning and its medico-legal importance.

COMPOUNDS OF ARSENIC

Table 1: Showing Inorganic Compounds of Arsenic [7]

Compound	Chemical formula	Common name	Properties
Arsenic tri oxide	As_2O_3	*Sankhiya*, white arsenic	White crystalline powder
Arsenic disulphide	As_2S_2	*Manhsheela*, Red arsenic	Red in colour
Arsenic trisulphide	As_2S3	*Hartal*, yellow arsenic, orpiment	Yellow in colour
Sodium arsenates	Na_3AsO_4	-	White, grayish
Potassium arsenates	$AsKO_2$	-	-
Arsenic acid	H_3AsO_4	Arseic pentoxide, Arsenic anhydride	White crystalline powder
Arsenic trichloride	$AsCl_3$	-	Colourless fuming liquid
Arsenic tri –iodide	AsI_3	Arseiuretted hydrogen, Arsenic hydride	Colourless and inflammable gas, garlic odour
Sodium arsenite	$NaAsO_2$	-	White powder
Copper arsenite	$AsCuHO_3$	Scheel's green	Greenish crystalline powder
Copper acetoarsenite	$Cu(C_2H_3O_2)_2.3Cu(AsO_2)$	Paris green	Greenish crystalline powder

Absorption, Excretion and Metabolism

Arsenic is absorbed through all routes mainly by skin, inhalation and GIT mucosa. Cutaneous absorption is low except in case of damaged skin. Inorganic pentavalent forms are absorbed higher rate than bivalent form. The absorbed inorganic arsenic undergoes methylation mainly in liver to monomethylarsonic acid and dimethylasinic acid and excreted through urine. After absorption, arsenic is redistributed to the liver, lungs, GIT, spleen, and kidney. It has minimal penetration in blood-brain barrier[7].

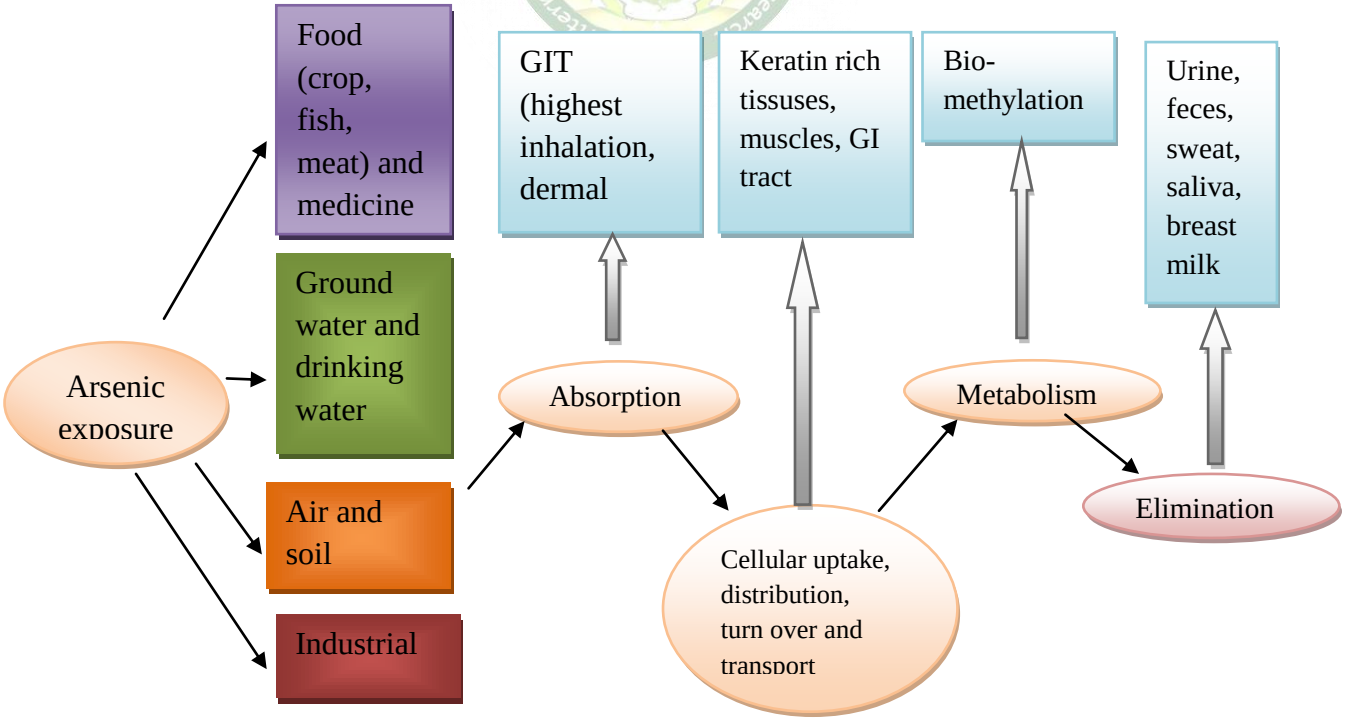

Figure 1 - Arsenic exposure and various steps in pharmacokinetics of arsenic

Toxicokinetics and Mode of Action

- Arsenic interferes with cellular respiration by uncoupling mitochondrial oxidative phosphorylation by combining with the sulphydryl groups of mitochondrial enzymes, especially pyruvate dehydrogenase and certain phosphatases. Consequently, conversion of pyruvate to acetyl CoA is decreased, citric acid cycle activity is decreased and production of cellular ATP is decreased.
- It inhibits cellular glucose uptake, gluconeogenesis, fatty acid oxidation and further production of acetyl CoA.
- Locally, it causes irritation of the mucous membranes, and remotely, depression of the nervous system.
- Arsenic can replace phosphorus in the bones where it may remain for years.
- Arsenic is a carcinogenic substance since lung, skin and bladder (transitional cell) carcinoma has been observed in populations with multiple exposures[8].

Toxicity

Acute arsenic poisoning is usually the result of accidental or suicidal ingestion of insecticides or pesticides. Toxicity is manifested by the stomach and intestine damage (diarrhea, vomiting, hemorrhage and electrolyte disturbances), muscle function disorders, cardiac arrhythmia and face edema. Arsenic acts as a local irritant causing local skin inflammation, ulceration etc. It also gets deposited in the hairs. Epidemiologic studies of arsenic in drinking water suggest that arsenic can cause skin, lung, liver, kidney and bladder cancer 1 in 1000 cases[9].

Arsenic poisoning clinically manifest in acute and chronic phase-

Acute Arsenic Poisoning[10]

- Acute exposures generally manifest with the cholera like gastrointestinal symptoms of nausea, vomiting, abdominal pain and severe diarrhea.
- In fulminant type, when large dose (> 3 g) is taken, the GIT symptoms are absent and death occurs in 1–3 h from shock and peripheral vascular failure.
- In narcotic type, the GIT symptoms are less. There is giddiness, formication, and tenderness of the muscles, delirium, coma and death. Rarely, there is complete paralysis of the extremities.
- Arsine gas exposure causes hemolysis, damages the liver and kidneys (hemoglobinuria and renal failure) and depresses the CNS. There is nausea, vomiting, shaking chills, backache and anemia. The urine appears black due to hemoglobinuria. Death may be preceded by anuria and convulsions.

Signs and Symptoms

- **GIT**- Sweetish metallic taste, nausea, projectile vomiting, burning in mouth and throat, and difficulty in swallowing, garlic odor in breath, intense thirst, pain in esophagus and abdomen, purging accompanied by tenesmus, pain and irritation about the anus. Initially, defecation is frequent and involuntary, dark-colored, but later it becomes colorless, odorless and watery resembling rice-water [11].
- **Renal**- Oliguria, uremia, albuminuria, Red cells and casts, pain during, micturition [12].
- **CVS**-Hypotension, pulmonary edema, ARDS, circulatory collapse, ventricular tachycardia and fibrillation.
- **Hepatic-** Fatty degeneration [13].
- **Muscles**- Pain and cramps in muscles [14].
- **CNS**- Headache, vertigo, hyperthermia, tremors, convulsions, coma, general paralysis[15].
- **Skin**- Delayed loss of hair, skin eruptions [15].

Fatal Dose[16]**:** 120–200 mg of arsenic trioxide (adults), 2mg/kg (children).

Fatal Period[17]**:** 1–2 days for acute poisoning, several weeks for sub-acute poisoning.

Chronic Arsenic Poisoning- (Arsenicosis or Arsenicism)

Chronic arsenic poisoning may occur due to:

- Accidental ingestion of small doses repeatedly by those working with the metal.
- Intake of food/drink in which there are traces of arsenic (may be homicidal in nature).

Signs and Symptoms

- **GIT**-Nausea, vomiting, abdominal cramps, loss of appetite, constipation or diarrhea, salivation [18].
- **Ocular**-Congestion, watering of the eyes, photophobia.
- **Respiratory System**- Cough, hoarseness of voice, bronchial catarrh, hemoptysis, dyspnea.
- **Skin and nails**- There may be a rash resembling fading measles rash. Speckled brown pigmentation, mostly on the skin flexures, temples, shoulders, eyelids and neck (raindrop pigmentation). Macular areas of depigmentation may appear on normal/ hyperpigmented skin leucomelanosis. Hyperkeratosis of the palms and soles with irregular thickening of the nails and development of white bands of opacity in the nails of fingers and toes (called Aldrich- Mees lines). Brittle nails and alopecia are also seen[19].
- **CNS**-Peripheral neuropathy with tingling, numbness of hands and feet, polyneuritis, anesthesias, paraesthesia with painful swelling

(erythromelalgia), encephalopathy. Neuritis resembles chronic alcoholism[20].

- **CVS-**Hypertension, ischemic heart disease, cardiac failure.
- **Renal**- Chronic nephritis, urine may be red or green in colour, dysuria and anuria may develop from renal tubular necrosis.
- **Hepatic**- Hepatomegaly, jaundice, cirrhosis of the liver[21].
- **Hematological**- Bone marrow suppression, hypoplasia, anemia, thrombocytopenia and leukemia[19].

Postmortem Findings in Acute Poisoning

1. External[22]

- The body presents dehydrated and cyanosed.
- The eyeballs are sunken.
- The skin is wrinkled and may be jaundiced.
- Rigor mortis appears early and lasts longer than usual.

2. Internal

- The stomach appearance is as Red velvet.
- The mucous appears red, oedematous and swollen in patches corresponding to deposit of arsenic particles [23].
- The mucous membrane of the mouth, pharynx and oesophagous may show inflammation or ulceration.
- Hemorrhages may be found in the abdominal organs and mesentery and occasionally in the larynx, trachea and lungs [24].
- Lungs- congested, pulmonary edema with subpleural ecchymoses.
- Heart-Subendocardial petechial hemorrhages of the left ventricle are common and may be found, even when the stomach shows little signs of irritation[25].
- Stomach- mucosa is swollen, edematous, desquamated and red, either generally or in patches, especially in the pyloric region. Usually, groups of petechiae are seen scattered over the mucosa, but sometimes large submucosal and sub-peritonial hemorrhages may be seen- red velvety appearance. A mass of sticky mucus covers the mucosa in which particles of arsenic may be seen. Congestion is most marked along the crest of the rugae. Inflammation is more marked at the greater curvature, posterior part and the cardiac end of the stomach[26].
- Small intestine- it contains large flakes of mucus with very little fecal matter. The mucosa is pale-violet and shows signs of inflammation with sub-mucous hemorrhages along its whole length.
- Cecum and rectum shows slight inflammation.
- Liver, spleen and kidneys- congested, enlarged and show cloudy swelling and occasionally fatty degeneration. Liver may show patchy fatty degenerative changes and less frequently necrosis with jaundice. Nephritis and scarring of renal cortices are seen.
- Brain- edema with patchy necrosis or hemorrhagic encephalitis. The meninges are congested[27].

In Chronic Poisoning

1. External

- Emaciation, pigmentation, keratosis, alopecia, white streaks on nail, jaundice, wasting of muscles and ulceration of nasal septum.
- Samples of hair and nails should be taken for analysis. For this purpose, hair must be complete with their bulbs and nails should be whole[28].

2. Internal

- Stomach- it may be normal or may show a chronic gastritis. Some rugae may show patchy inflammatory redness or focal ulceration.
- Small intestine- dilated, reddish with thickened mucosa [29].
- Liver- hepatomegaly, fatty degeneration or even necrosis with non-cirrhotic portal fibrosis.
- Kidneys- tubular necrosis, fatty degeneration.
- Heart-myocardial necrosis and fatty degeneration[30].
- Arsenic is also deposited at the end of long bones which may be examined for the presence of poison. A few centimeters of the shaft of lower end of femur is suitable for this purpose.

Medico-Legal Aspects

Arsenic poisoning can be homicidal, suicidal, accidental, occupational, environmental, iatrogenic or uniatrogenic.

1) Homicide- arsenic is popular homicidal poison because- It is cheap, easily obtained, colourless, tasteless, odorless, small quantity is required to cause death. It can be easily administered with food or drink. Its onset of symptoms is gradual [31]. Symptoms stimulate those of cholera

Table 2: showing differences between arsenic poisoning and cholera [32]

S.No.	Trait	Arsenic poisoning	Cholera
1	Pain in throat	Before vomiting	After vomiting
2	Purging	After vomiting	Before vomiting
3	Stool	Dark coloured and bloody, later rice- watery.	rice- watery, not bloody and passed continuous involuntary
4	Tenesmus and anal irritation	Present	Absent
5	Vomited matter	Contains mucus, bile and blood	Watery without mucus, bile and blood
6	Voice	Not affected	Rough and whistling
7	Conjunctivae	Inflamed	Not inflamed
8	Analysis of excreta	Arsenic present	Cholera vibrio present
9	Circumstantial evidence	Arsenic poisoning may be present	Other cases of cholera in locality.

The disadvantages for homicide is

- It delays putrefaction.
- Can be detected in completely decomposed body.
- Cab be found in bones, hair and nails for several years.
- Can be detected in charred bones or ashes.

2) Suicide- it is rare, because it causes too much pain[33].

3) Accidental- accidental death may be due to admixture with articles of flood or from its improper medicinal use. Poisoning in children may occur, if they chew paint or eat vermin or bait or ant syrup containing arsenic. Chronic poisoning results from drinking well water containing arsenic[34].

4) Occupational- arsenic exposure can be occupational in those working in metal factory, mining, glass production or in the semiconductor industry.

5) Environmental contamination of water sources has become a major problem in many countries, including India[35].

6) It is sometimes ingested or applied locally in the form of a paste or ointment on abortion sticks to procure abortion[36].

7) It may be used as cattle poison [37].

Postmortem Imbibition of Arsenic

- Arsenic is the 12th most abundant element on earth. In exhumations, the possibility of imbibitions of arsenic from stomach into neighboring viscera and also contamination from the surrounding earth should be remembered. Arsenic found in the soil is usually an insoluble salt.
- Keratin tissues absorb arsenic by contamination from outside. The concentration in hair and nails thus contaminated is likely to be much greater than the concentration of arsenic in the contaminating fluid.
- If arsenic is introduced into the stomach after death, the transudation occurs into the organs of the left side before those of the right and the signs of inflammation and ulceration are absent[38].

DISCUSSION

Metallic arsenic is not poisonous as it is insoluble in water and non-absorbable from GIT. However it becomes poisonous when it is oxidizes on exposure to air and gets absorbed. Its local application causes necrosis and sloughing. Arsenic inhibits sulphydryl enzymes system which is necessary for cellular metabolism. Acute poisoning symptoms usually appear within half an hour and GIT symptoms predominate. Acute arsenic poisoning has to be differential from cholera. Post-mortem appearance shows in acute arsenic poisoning rigor mortis lasts longer than usual, shrunken eye balls and jaundiced skin and sometimes cyanosis may be present. Mucous membrane of stomach swollen, softened congested, tinged with blood spots and white particles of arsenic embedded in it, colour varying from brownish-red or bright scarlet. In chronic arsenic poisoning shows fatty degeneration of the liver, kidneys, heart and acute encephalitis with hemorrhagic spots of brain. Arsenic poisoning can be homicidal, suicidal, accidental, occupational, environmental, iatrogenic or un-iatrogenic.

CONCLUSION

It is an ideal homicidal poison cause cheap, easy availability and very small quantity is needed to produce fatal effects. It can easily be put in the mouth after mixing with food articles, wine or medicines, *Paan*, tobacco or cigarette. Hence this article detail

explained about arsenic poisoning and its post-mortem findings.

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