

DIAGNOSTIC METHOD OF CHRONIC MERCURY TOXICITY AND ITS AYURVEDIC MANAGEMENT

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ABSTRACT

Long term hazards due to prolong persistent continuous exposure of mercury causes chronic cumulative toxicity in human beings. Heavy industrialization, gold mining, utilization of fishes as a food containing methyl mercury and utilization of Ayurvedic Ras Aushdhi containing Mercury, these problems are increasing day by day. Long term exposure of mercury causes mercuria lentis, Neurological toxicity, Hatter's Shake, concussion mercurialis, Mercurial erethism and some psychological problems. It also causes immunotoxicity as well as some nonspecific signs like anorexia, insomnia, headache and lassitude.

Mercury and its toxicity are not new for Ayurveda and Ras Aushdhi containing mercury has found descriptions after Nagarjun kal. Vomiting, Belching, Restlessness, Excessive thirst, kushta/ leprosy, Boils Body temperature increases. These are some long term hazards of parad yog in human beings which is described in ras shastriya text. History of long term exposure of mercury, signs and symptoms of chronic toxicity and laboratory investigations for mercury level in hair, blood and urine should be help to confirm the chronic mercury toxicity. Induce emesis by 2-3 lts of kwath of 10grm Dhamargav (*Luffa cylendrica*) and induce purgation by 4grm snuhi (*Euphorbia nerifolia*) mixed with 100ml trivrit (*Operculina turpethum*) kwath should be help to remove the accumulated mercury on cellular level. Yog-Basti having Vata Nasaka Anuvasan Basti and Pakwashya Shodhak Niruh Basti should be help to pacify the vat prakop. Ajit agad, kalayank sarpi, brahami should be helpful in anorexia, anaemia, psychological disorder respectively. Thus chronic toxicity of mercury should be managed by using ayurvedic principle and drugs.

KEYWORDS: Mercury, Mercury toxicity, chronic toxicity, Ayurveda.

1. INTRODUCTION

It is estimated that mercury elimination will increase at a rate of 5% per year in air due to coal smoke.^[1] Water sample from Haryana had found the highest level of mercury at a concentration 268 times that of the safe limit during survey.^[2] Mercury is a heavy metal which causes acute as well as chronic cumulative toxicity to human beings. Due to industrialization, the emission of mercury has been increased, which produces long-term hazards to human beings. Ayurveda is an ancient science, and the mercury, its therapeutic preparation, its acute and chronic toxicity has been found in detail. The therapeutic utilization of mercury has increased after Nagarjun Kal 8th, who is the father of Ras Shastra.^[3] Though its acute/chronic toxicity and its management is also found in Ayurveda, but the subject matter is scattered. Diagnostic methods and its ayurvedic management have been evaluated, elaborated and discussed in this original, fundamental research article on chronic mercury toxicity.

2. Sources of exposure to mercury

2.1.1 Industrial processes

Most of the mercury in the environment results from human activity, particularly from coal-fired power stations, residential heating systems and waste incinerators. Mercury is also present as a result of mining for mercury, gold (where mercury is used to form an amalgam before being burnt off), and other metals, such as copper, zinc and silver, as well as from refining operations.^[4]

2.1.2 Artisanal and Small-Scale Gold Mining (ASGM)

Mercury is used in gold mining to extract gold from ore by forming “amalgam” – a mixture composed of approximately equal parts mercury and gold. The amalgam is heated, evaporating the mercury from the mixture, leaving the gold.^[5] This method of gold extraction is used in the ASGM community because it is cheaper than most alternative methods, can be used by one person independently and is quick and easy.^[6] On a global basis, ASGM is responsible for approximately 37% of mercury emissions and is the largest source of air and water mercury pollution.^[7] Mercury vapours in the air around amalgam burning sites can be alarmingly high and almost always exceed the WHO limit for public exposure of 1.0 µg/m³. These exposures affect not only ASGM workers but also those in the communities surrounding the processing centers.³ The vaporized mercury eventually settles in soil and the

sediment of lakes, rivers, bays, and oceans and is transformed by anaerobic organisms into methyl mercury. In water bodies, the methyl mercury is absorbed by phytoplankton, ingested by zooplankton and fish thereby contaminating the food chain. It especially accumulates in long-lived predatory species including shark and swordfish.^[8]

2.1.3. Food

Eating contaminated fish and shellfish is the main source of methyl mercury exposure, especially in populations that rely heavily on consumption of predatory fish. Cooking does not eliminate mercury from fish. WHO is preparing a guidance document for risk managers that will use national exposure assessments to determine the appropriate risk management options, bearing in mind the nutritional benefits of fish consumption. In addition, WHO is launching an initiative to estimate the global burden of foodborne disease, including the burden of disease from ingested mercury.^[9]

2.1.4. Elemental Mercury Sources

Silver “amalgam” dental fillings typically weigh between 1.5-2.0 g, with approximately 50% of the material being elemental mercury. When no chewing occurs, individuals with amalgam fillings on occlusal surfaces have been found to have oral levels of mercury vapour nine times greater than those without amalgams. Upon chewing, the same individuals had a six-fold increase in oral elemental mercury levels, resulting in a 54- times greater level of mercury vapour in their oral cavities than persons without amalgams.¹⁵ Serial measurements of these individuals found mercury concentrations remained elevated during 30 minutes of continuous chewing, and then declined slowly over 90 minutes after chewing ceased.¹⁶ Based on the relatively small size of the trial (35 subjects) the researchers concluded individuals with 1-4 occlusal amalgams would be exposed to an average daily dose of 8 µg elemental mercury; those with 12 or more occlusal amalgams were estimated to receive 29 µg per day, and the average of all 35 subjects was estimated at 20µg per day. Individual cases have been published showing urinary mercury excretion to be 23-60 µg/Hg/day (25-54 µg/g keratinise) indicating a daily intake as high as 100 µg.¹⁷ In these individuals, bruxism and gum chewing were noted as probable causes of the high mercury output, which fell back to normal levels with amalgam removal. Higher levels of mercury release from dental amalgams have also been found with tooth brushing¹⁸.^[10]

2.1.5 Mercury Exposure Sources

Mercury is still used today in some medicines as a preservative, being present in this form in various vaccinations. Mercury poisoning has occurred from mercury in abandoned industrial sites. In Texarkana, Arkansas, teenagers found two pints of mercury in an abandoned neon sign plant, resulting in one hospitalization and seven homes being evacuated by the EPA. A more serious incident occurred in New Jersey in 1995, where a five-story factory building used to manufacture mercury vapour lamps in the 1930s was converted into condominium apartments. When residents reported finding standing pools of mercury on the countertops and floors, local health agencies were contacted. Air mercury levels were found to range from 5 µg/m³ to 888 µg/m³ (over visible pools of mercury on the floor). Sixty-nine % of the residents had urinary mercury levels greater than 20 µg/l.^[11] Comparisons of urine at the time of evacuation from the building and 10 weeks later showed no significant differences.^[12] Former residents with the highest urinary mercury levels exhibited the most errors on a test of fine motor function, and reported the most somatic and psychological symptoms. In another residential poisoning, mercury vapour was spread by the use of the family vacuum cleaner, which had been used to clean up mercury from a broken thermometer. Continued use of the vacuum cleaner spread mercury droplets throughout the house. A two year- old girl developed nephrotic syndrome and her three-year-old brother had significant neurological problems.^[13] Mercury poisoning has also been found in persons living proximal to an inactive mercury mine in California^[14] and in individuals from several states using Cream de Belleza-Manning facial cream. This cream was found to contain 6-10% mercury, while the facial cream Nutrapeil Cremaning Plus was found to have 9.7% mercury.^[15]

2.2 Ayurvedic sources^[16]

There are so many mercury compounds had have being used for prevention and cure of diseases since 11th century. The classical ayurvedic preparation are broadly classified in 1. Khraliya rasayan like Kajjali, Tribhuvankritiras, Aarogyavardhani vati, Ras Parpati, 2. Parpati Rasayan like Ras Parpati, Swaran Parpati, Panchamrit Parpati, Tarma parpati, Vijaya Parpati, Gagan Parpati, Vol Parpati, 3. Kupipakkav Rasayan like Ras Sindoor, makar Dhvaj, Raskarpoor, Sameerpannag Ras, Ras pushpa and 4. Potalirasayan like Rasgarbha, hemgarbha.

3. Mercury compounds

1. Mercuric Oxide HgO- Mercuric oxide is a brick red crystalline powder but it forms an amorphous yellow powder when a mercuric salt is acted upon by caustic soda or potash.

2. Mercuric chlorides - HgCl_2

Mercuric chlorides exists in the form of heavy, colourless masses of prismatic crystals or as a white crystalline powder. It has a styptic, nauseous metallic taste.

3. Mercuric Iodide - HgI_2

Mercuric Iodide is also called red iodide of mercury or biniodide of mercury. It is a scarlet red powder obtained by the action of a watery solution of mercuric chloride on potassium iodide.

4. Mercuric Cyanide - $\text{Hg}(\text{CN})_2$

Mercuric Cyanide is a fungicide nearly as poisonous^[17] as a corrosive sublimate. But has no corrosive action.

5. Mercuric Cyanide - $\text{Hg}(\text{CN})_2$ - Mercuric Nitrate is crystalline, but deliquescent. It is used for painting on porcelain and in veterinary medicine.

6. Mercuric Sulphide - HgS - Mercuric Sulphide occurs as the chief ore of mercury and is artificially prepared as a red, crystalline powder, which is then known as the pigment vermilion.

7. Mercuric sulphate - HgSO_4 Mercuric sulphate is a white crystalline powder and acts as a corrosive poison. It has been administered in mistake for sulphocarbonate of sodium and has caused death. It has also been taken with a suicidal intent.

8. Mercuric Fulminate - $\text{Hg}(\text{ONC})_2$ Mercuric Fulminate is used in factories where percussion caps and deton. are made. It produces an erythematous rash on the exposed parts of the body with severe itching and ulcers on the nail beds and tips of fingers.

Mercuric methide (Mercury Dimethyl) ($\text{Hg}(\text{CH}_3)_2$) Mercuric methide is a highly poisonous liquid and has caused death by the inhalation of its noxious vapour. It also produces insanity.

9. Mercurous nitrate $\text{Hg}_2(\text{NO}_3)_2$

Mercurous nitrate is colourless and crystalline. It is soluble in water acidulated with nitric acid and is as poisonous as mercuric nitrate.

10. Novasurol (merbaphrn)- Novasurol is just a double salt of sodium mercurichlorophenyl oxyacetate with diethyl- barbituric acid. It is a white crystalline solid, soluble in water, and contains 33.9 per cent of mercury. it is a powerful diuretics, the dose being ½ to 2 ml of 10 per cent solution through an intravenous or intra – muscular injection.

4. Mercury and its compound causes specific and nonspecific hazardous in human being

4.1 Nonspecific sign^[18]

1. Excessive salivation with metallic taste in mouth with painful inflamed gums and occasionally a blue- black line on the gums, Anorexia ,insomnia, abnormal sweating, Headache, Lassitude.

4.2 Specific sign^[19]

1. Mercuria lentis may be the early symptom of chronic poisoning exhibitibg in the form of discolouration of the anterior capsule of the lens of eye due to deposition of mercury.

2. Neurological toxicity is manifested by tremors. It is one of the most characteristic and consistent manifestation of chronic mercury poisoning and is sometimes referred to as **Danbury tremor**. It is coarse, intentional and affects the hands, arms, tongue and later the legs. The advanced condition is referred to as **Hatter's Shake** (Because it was common in workers of that industry).

3. The most severe form of the condition is referred to as **concussio mercurialis** when literally no activity is possible. Tremor may persist even years after exposure to mercury has ceased.

4. Mercurial erethism is a peculiar disturbance of the personality and comprises of constellation of finding including excitability, memory loss, insomnia, timidity and sometimes delirium that was described in workers with occupational exposure in the felt –hat industry hence the expression “**mad as a hatter**” (It has been suggested that Lewis Carroll's mad hatter may really have been suffering from mercury poisoning, as did many hatters of the 1800s).

5. Psychological Symptoms of Mercury Overload.- Irritability, Excitability, Temper outbursts, Quarrelling, Fearfulness/anxiety, Restlessness, Depression, Insomnia.. **Mercury Immunotoxicity-** Autoimmunity, Decreased cellular immune function, Apoptosis of

monocytes and lymphocytes, Decreased phagocytosis, Decreased production TNM alpha.II-1, increased release of ACTH and Cortisol.

4.3 In addition, different compounds produce specific sign and symptoms of poisoning as under

(a) Elemental Mercury Poisoning: Tremors, Changes in nerve responses, Neuromuscular changes (such as weakness, muscle atrophy, twitching), Disturbances in sensations, Emotional changes (e.g., mood swings, irritability, nervousness, excessive shyness), Insomnia, Headache, Performance deficits on tests of cognitive function.

(b) Methyl Mercury Poisoning^[20]

Impairment of the peripheral vision, Disturbances in sensations ("pins and needles" feelings, usually in the hands, feet and around the mouth), Lack of coordination of movements, Impairment of speech, hearing, walking and muscle weakness.

(c) Inorganic Mercury^[21]

Skin rashes, mood swings, memory loss, mental disturbances, muscle weakness.

5. Long term hazardous of Ingestion of Parad Yog in human being^[22,23,24]

There are also some patent ayurvedic medicines of mercury which have been used in different disease. The utilization of these traditional or patent drugs having mercury is as an ingredient since prolong period may also cause long term hazards.-

Table no. 1.

S.N.	Symptoms	R.R.S	R.T	R.S
1.	Vomiting/Vaman	✓		
2.	Belching	✓		
4.	Restlessness	✓		✓
5.	Excessive thirst	✓		
6.	kushta/ leprosy			✓
7.	Death	✓	✓	✓
8.	Boils		✓	
9.	Body temperature increases		✓	

R.R.S- Ras Ratan Samuchaya, R.T- Ras Tarangini, R.S- Rasendra SambhavS.

6. Laboratory investigation to detect chronic mercuric toxicity in human being

6.1 Laboratory investigations of chronic mercury level in hair/blood/urine

It is important to investigate for chronic mercury poisoning of any worker, who excretes more than 0.3 mg of mercury per liter in the urine.^[25]

Several methods for assessing mercury contamination have been used, including hair, Urine and blood. Methyl mercury shows up very well in the hair, which has been the Primary testing measurement of Amazonian children⁶¹ and people from the Mina Mata Bay area.⁸⁹ some methyl mercury studies use a combination of urine and hair, both of which appear to be sensitive markers that correlate significantly with each other.⁹⁰ Elemental mercury (from amalgams) does not show up well in the hair. ²⁴ In fact, other hair mercury studies have shown hair mercury levels are 79-94% methyl mercury, leaving only 6-21% as elemental mercury.⁸⁹ With such a low affinity of elemental mercury for the hair, one may have a significant amount of elemental mercury and exhibit no presence of such on the hair test. Since mercury binds tightly to selenium and sulphur, it has been suggested that low mercury and high sulphur and/or selenium on hair testing indicates a body burden of elemental mercury.⁹¹ Elemental mercury from amalgams shows up best in the plasma and urine.⁹² While 24-hour urine samples are generally used in such studies, in males no diurnal variations are found in mercury excretion and the first morning urine shows strong correlation with the twenty-four hour sample.⁹³ Women do exhibit a diurnal pattern in urinary mercury excretion, leaving the 24- hour sample as the best way to measure mercury.

6.2 Comparison of methyl mercury limits^[26,27,28,29,30]

Table no. 2.

			Levels corresponding to the intake dose
	INTAKE DOSE	HAIR	BLOOD
FAO/WHO Joint Expert Committee on Food Additives (JECFA)	1.6 µg/kg body weight Provisional Tolerable Weekly Intake (PTWI) ⁱ	14 mg/kg ⁱⁱ 2 µg/ gram corresponds approximately to the PTWI	
US EPA reference dose US National Research Council (NRC)	0.1 µg/kg body weight per day. ⁱⁱⁱ OR 0.7 µg/kg body weight per week	1 µg/ gram of hair ^{iv}	5.8 µg/L ^v

6.3 Laboratory investigation of chronic mercury level in blood/ urine^[31,32]

Table no. 3.

Patients	Blood*	Urine**
Unexposed persons	520 nmol/L 54 mg/L	550 nmol/24 h (510 mg/24 h), or 55 nmol/mmol creatinine (510 mg/g)
Dental workers		510 nmol/mmol creatinine (520 mg/g)
Industrial workers	595 nmol/L	545 nmol/mmol creatinine (590 mg/g) Organic 515 nmol/mmol creatinine Inorganic 5120 nmol/ mmol creatinine

*Lithium heparin or ethylene diaminetetra-acetic acid (EDTA) whole blood, 10mL in a hard plastic or glass tube.

**24 h collection in a hard plastic bottle washed with nitric acid, or an early morning sample in a sterile universal. (Dianne R Baldwin and William J Marshall.

From the Department of Clinical Biochemistry, King's College Hospital, London SE5 9RS, UK Heavy metal poisoning and its laboratory investigation)s.

7. Ayurvedic Management of the long term hazardous of Parad^[33]

If there is long term hazards like vaman and belching due to ingestion of parad yog in patient will found than powder of jeerak With curds and rice should be given. If there is any neurological manifestation (Vat prakop). Then abhayang(massage) should be given by vat nashak narayanl tail. If patient feel agitation or restlessness than head bath(abhishek) with cold water will be given. If patient feel excessive thirst than nariyal water or sugar water of moong ush should be given.

7.1 Sanshodhan

a) Vaman^[34]

Pradhankarma- Vaman(Induced emesis)- After proper physical examinations patient is ask to complete shauch vidhi before the procedure of vaman will started in the early in morning. Then vamnopag dravya (assistant drugs for vomiting) will be given in the dose of 2-3 liters than Dhamargav(*Luffa cylendrica*) Mushti praman 10gram will be liked for inducing

emesis. Vaman veg will be noted and counted and recorded. Emetic material will be collected in transparent glass water measure and observes for any abnormality effect. The adverse effect or any complications will be noted and managed.

Sansarjan Kram- The sansargen kram will be followed as per indicated in panchkarma. Patient should be given liquid light diet (peya) in in frst day evening, second day morning and evening followed by semisolid liquid diet. Third day (vilepi) and \$th day morning. Then Mung dal water (Soup) up to seventh day.

b) Verechan (Induced purgation)^[35] - After proper examination of the patient the procedure of virechan started early in the morning. Snuhi(*Euphorbia nerifolia*) in 4gram will be given mixed with trivrit(*Operculina turpethum*) kwath 100ml. The virechan vegas will be countered and recorded.

Sansarjan Kram-The sansargen kram will be followed as per indicated in vaman karm.

c) Basti^[36]

Yog basti havig vat nashak anuvasan basti and pakwashaya shodhak niruh basti should be used to pacify to prakopak vat due to chronic Hg toxicity. it should be given alternate in manner means first anuvasan than niruha(1:3:3:1) vat nasak anuvasn basti contening Bael, Artni, sonapatha, Gambhari and Patala should be given in 120ml in quantity after meal. Pakwashya shodhak basti contening kwath of madan phal, Devdali, tillaouki ke beej, Dhamargav, Indrayav these drugs prepared with cow's urine should be given 400ml empty stomach.

7. 2. Sanshaman

7.2.1 Symptomatic

Ajit agad^[37], Kalayank sarpi^[38], Brahami^[39] should helpful in anorexia, anaemia psychological disorder respectively.

Ayurvedic anti dote- Draksha, kusmand, tulsi, shatpushpika, lavang, dalcheeni, nagkeser, out of these drugs only one drug is taken with same amount of gandhak and milk.^[40]

DISCUSSION

The chronic toxicity of mercury has being increased all over the world including India. The main sources of exposure of mercury are Industrial processes, Artisanal and Small-Scale

Gold Mining (ASGM), Elemental Mercury Sources, Ayurvedic drugs containing mercury which causes excessive emission of mercury? Thought the poorer mercury in metallic state not produced the toxicity but the toxic compound like HgS, HgO, HgCl₂, HgI₂, Hg(CN)₂, HgSO₄, (Hg₂(NO₃)₂) produces the toxicity in human beings. Mercuria lentis, Mercurial erethism, “mad as a hatter”, concussion mercurialis, are the specific signs of chronic cumulative toxicity of mercury while anorexia, insomnia, abnormal sweating, Headache, Lassitude are nonspecific signs. Ayurveda has also describe the long term of Hazardous of ingestion of mercury like vomiting, Belching, Restlessness, Excessive thirst, kushta/ leprosy, Boils, Body temperature increases. Which is somewhat similar to nonspecific signs mention in modern science? The confirm diagnosis should be done by evaluating the mercury level in hair blood and urine. After confirmation of chronic mercury toxicity patient should be subjected for induce emesis, induce purgation and yog basti in periodic interval. To 2-3 lt of kwath of 10grm of Dhamargav(*Luffa cylendrica*) should be given for emesis. After sansargan karm 4grm snuhi mixed with 100ml kwath of 3grm of trivit should be given. Yog basti should be subjected by using vat nasak anuvasan basti and pakwashya shodhak niruha basti should be given in alternate manner after proper sanshodhan, the ayurvedic anti dote contening draksha, kusmand, tulsi, shatpushpika, lavahg, dalcheeni, nagkeser, to pacify the accumulated dosha. The mercury not completely removed by sanshodhan karm. Ajit agad, Kalayank sarpi, brahami should be given respectively.

CONCLUSION

Chronic cumulative mercury toxicity is a global health challenge including India. Induce emesis by Dhamargav (*Luffa cylendrica*), induce purgation by snuhi(*Euphorbia nerifolia*) and yog basti should be given to remove the accumulative mercury and its metabolites which helpful to manage chronic cumulative toxicity of mercury along with ayurvedic antidote and symptomatic management.

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