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Arsenic safe water and changes in severity of arsenical symptoms

Kunal Kanti Majumdar¹, Mahesh Kumar Goyal²

¹Professor, Department of Community Medicine, KPC Medical College and Hospital, Jadavpur, Kolkata.

²Assistant Professor, Department of Community Medicine, KPC Medical College and Hospital, Jadavpur, Kolkata.

Corresponding author:

Dr Kunal Kanti Majumdar,
Department of Community Medicine,
KPC Medical College and Hospital, Jadavpur,
Kolkata. E-mail: kunalmajumdar1@gmail.com

Abstract

Limited information is available in the literature regarding the long-term effect of chronic arsenic toxicity after stoppage of consumption of arsenic-containing water. Treatment options for the management symptoms of chronic arsenicosis are also limited. Mitigation option available for dealing with the health problem of ground water arsenic contamination rests mainly on supply of arsenic safe water in arsenic endemic region of Indo-Bangladesh subcontinent. The current study was therefore done to study the prevalence of arsenicosis and to assess the effect of

drinking arsenic safe water (<50µg/L) on disease manifestation of arsenicosis. Manifestations of various skin lesions and systemic diseases associated with chronic arsenic exposure was ascertained initially by carrying on baseline study on 191 families having 1097 family members along with 44 children studying in Chouduar Primary School in Chouduar village of Malda District of West Bengal. The study population was taking water solely from a particular Chouduar primary school tube well with arsenic level >50 µg/L. The base line study findings were

Address for correspondence:

The Editor/ Managing Editor,
Journal of Comprehensive Health
Dept of Community medicine
NRS Medical College,
138, AJC Bose Road, Kolkata-700014

compared objectively at the end of six months follow up period after installation of a community filter at the Chouduar primary school tube well. Around 11.36% of school children had clinical features of suspected arsenicosis with mild keratosis either in the palm or sole. The prevalence was more common in males. 15.8% of the remaining study population was having one or more dermatological and non dermatological manifestations of arsenicosis and there was 1.94% decrease

in prevalence of non dermatological manifestations without any change in dermatological manifestations after taking arsenic safe water at the end of 6 months of follow up study. Around 70% of population was not aware about adverse health effects of arsenicosis and not taking animal protein regularly.

Key words: Arsenic and skin manifestations, Arsenic and systemic manifestations, Arsenic and safe water, Treatment of arsenicosis.

Introduction

Arsenic pollution in groundwater, used for drinking purposes has been envisaged as a problem of global concern. Arsenic contamination in drinking water has been reported from many countries, but the severity of this contamination in India and Bangladesh is unprecedented. In India, occurrences of arsenic in groundwater have also been reported from Bihar, Jharkhand, Chhattisgarh, Uttar Pradesh and Assam ^[1].

Over and above pigmentation, keratosis, arsenicosis produces protean manifestations like weakness, chronic respiratory disease, peripheral neuropathy, liver fibrosis, peripheral vascular disease etc. ^[2, 3] Chronic arsenicosis leads to irreversible damage in several vital organs, and arsenic is an established carcinogen.

Despite the magnitude of this potentially fatal toxicity, there is no effective therapy for this disease; patients once affected may not recover, even after remediation of the arsenic-contaminated water. The need for an effective therapy for chronic arsenicosis is obvious. Chelation therapy for chronic arsenic toxicity is thought to be the specific therapy for relief of systemic clinical manifestations and reduction of arsenic stores in the body, reducing subsequent cancer risk. Chelation therapy is presumed to be more effective with early features of the toxicity, as severe manifestation of polyneuropathy, chronic lung and liver disease, swelling of hands and legs, and defects of hearing and vision are less likely to respond to this therapy. Chelating agents like *meso-2,3-*

dimercaptosuccinic acid (DMSA), sodium 2,3-dimercapto-1-propane sulfonic acid (DMPS) and d-penicillamine have frequently been considered for treatment of chronic arsenic toxicity. However, their usefulness as a standard method of treatment is yet to be established. [4,5] Anti oxidants and vitamins are also been tried by some workers for the treatment of arsenicosis.[6] But no authentic evidence on the basis of placebo controlled trial has been available substantiating the efficacy. Earlier decrement of clinical score of arsenicosis was reported following drinking of arsenic safe water in a hospital based study on 10 patients of arsenicosis who were also given high protein diet [4]. In a community based study interventions

Methodology

A longitudinal intervention study was conducted from January 2015 to September 2015 in Chouduar village of Malda District of West Bengal to assess the occurrence of various dermatological and non dermatological manifestations of arsenicosis and the effect of taking safe water on these manifestations.

Seven Blocks of Malda District were endemic for arsenicosis, of which Ratua II Block was selected randomly for the study. In the selected Block the village Chouduar

by reducing supply of arsenic contaminated water in a Southern Thailand showed both regression and progression of skin lesion, though the majority of the subjects followed up remained the same. [7] However, no objective evaluation of decrement of skin score on intake of arsenic safe water was done in that study. Further, no report is available in regard to change in systemic disease features following intake of arsenic safe water in an arsenic endemic population.

The current study was therefore done to study the prevalence of arsenicosis and to assess the effect of drinking arsenic safe water (<50µg/L) on disease manifestations in regard to dermatological and systemic disease manifestation.

where there was no safe source of drinking water was selected randomly and a community filter was installed as an intervention measure. Arsenic content of the tube well in that area was >50 µg/L (PHED report Govt. of West Bengal 2008). 191 families having 1097 family members along with 44 children studying in Chouduar Primary School taking water solely from a particular Chouduar primary school tube well with arsenic level >50 µg/L was selected as study population. A community filter was installed in February

2015 at Chouduar Primary School. The selected families and the school children started using community filter water with Arsenic level below permissible limit of $<50 \mu\text{g/L}$ for drinking and cooking purposes. The water samples were tested by Indian Institute of Engineering Science and Technology (IEST), Shibpur. So he selected families along with 44 children studying in Chouduar Primary School had a past history of taking water from an unsafe source before taking water from the community filter. The supplied filter removes Arsenic by adsorption method with activated alumina used as adsorbent along with electro coagulation which is a standardized method of removing Arsenic from water designed by IIT, Kharagpur supported by UNICEF and accredited by PHED, Govt. of West Bengal.

Ethical clearance was done prior to the initiation of the study. After taking consent from Headmaster of the school, 44 students of class II to class IV (7 to 9 years of age) were screened for suspected arsenical skin lesions. The history of exposure to water containing arsenic level above permissible limit was verified with their residential address. The students having keratosis suspected to be due to arsenicosis were re-examined in the

follow up visit to determine the changes in manifestations of keratosis six months after consumption of safe drinking water from the supplied community filter. The data obtained was compared with the collected data of the baseline survey at first visit. After taking informed consent, the family members were also interviewed for their drinking and cooking water source for baseline data using a check list. They were also clinically examined for presence of signs and symptoms of suspected arsenicosis. Arsenical Manifestations was assessed by case definitions and diagnostic criteria of WHO (WHO Technical Publication, 2005)⁸. The family members were then motivated to use only filter water for their drinking and cooking purposes and were monitored continuously by the fieldworkers. The family members were subsequently re-examined in the months of September 2015 to determine the changes in clinical manifestations. The data obtained was compared with the baseline survey data. During follow up visit enquiries were made regarding any difficulty in using the filter water. Data collected were analyzed by suitable statistical methods.

Counseling, advice and treatment of minor ailments were also given to family members.

Results

Out of 44 school children screened for arsenicosis around 11.36% of children were having clinical features of suspected arsenicosis with mild keratosis either in the palm or sole as found in the baseline survey and all of them were drinking water from the school tube well containing arsenic level above permissible level. Among 11.36% of children having clinical features of suspected arsenicosis 15% were

male children and 8.33% were female children thereby, showing increased prevalence of arsenicosis in males (Table I). All the children suffering from suspected arsenicosis were between 8- 9 yrs of age. In the follow up survey after drinking water from the installed school community filter for 6 months there was no change in the prevalence of suspected arsenicosis among them.

Table I Distribution of school children according to suspected arsenicosis in both baseline (January 2015) and follow up survey (September 2015)

	Male (n=20)	Female (n=24)	Total(n=44)
Suspected Arsenicosis	3 (15%)	2 (8.33%)	5 (11.36%)

Baseline study conducted in the field area among 1097 participants belonging to 191 families showed that over all prevalence of pigmentation and or keratosis was around 1.6% and there was no change in prevalence of pigmentation and or keratosis in follow up survey (Table III). Majority cases of pigmentation and keratosis were mild.

15.8% and 13.64% of population had one or more dermatological and non

dermatological manifestations of arsenicosis in the baseline and follow up survey. So there was 1.94% decrease in prevalence in the follow up survey and this decrease was mainly among the non dermatological manifestations. (Table III). Among non dermatological manifestations 5% of the population complained of dyspepsia in the baseline survey (bloating, flatulence and a sense of distension in the upper part of abdomen.) with 0.36 % decrease in follow up survey (Table

III).Chronic cough (3.8%), weakness (3.09%), conjunctivitis (1.30%) and bilateral oedema of the legs (0.45%) were the other systemic manifestations present in the baseline survey with 0.4%, 0.18%

decrease of chronic cough and weakness in the follow up survey. (Table II) Only 30% of population was aware about adverse health effects of arsenicosis.

Table II Distribution of study population according to prevalence of signs and symptoms of suspected cases of arsenicosis (n=1097)

Symptoms/signs of suspected case of arsenicosis	Prevalence on baseline survey on January 2015 No (%)	Prevalence on follow up survey on September 2015 No (%)	Change in Prevalence in follow up survey (%)
Pigmentation spotty	8 (0.73)	8 (0.73)	No change
Keratosi	9(0.91)	9(0.91)	No change
Chr. Lung Disease (Chronic cough)	41(3.8)	38(3.4)	-0.4%
Weakness	34(3.09)	32 (2.91)	-0.18
Dyspepsia	54 (5)	51 (4.64)	-0.36
Conjunctivitis	14 (1.30)	14 (1.30)	No change
Non pitting edema	5 (0.45)	5 (0.45)	No change
Diabetis	2 (0.2)	2 (0.2)	No change
Ischaemic Heart Disease (IHD)	1(0.1)	1(0.1)	No change

(figures inside parenthesis indicate percentage)

31.7% of study population was taking egg/fish/ meat twice or thrice a week which are rich source of animal protein.40% of population was taking plenty of green leafy vegetables and seasonal fruits which are rich in anti oxidants.

The families taking water from community filter were satisfied about the water regarding its taste, palatability. So the filter water was quite acceptable to them.

Discussion

This study describes the prevalence of various dermatological and non dermatological manifestations of arsenicosis along with clinical profile and impact of drinking safe water (As level <50 µg/L) on amelioration of symptoms of chronic arsenic toxicity among people living in one of the arsenic-affected district of West Bengal. Significant chronic arsenic exposure was documented in the arsenic-exposed people in the study area. Around 11.36% of school children were having clinical features of suspected arsenicosis with mild keratosis either in the palm or sole. There was increased prevalence of arsenicosis in males and all the children suffering from suspected arsenicosis were between 8- 9 yrs of age. Arsenical skin lesions were reported in 144 school children in Antofagasta, Chile during a cross-sectional survey in 1976. The investigators further reported that chronic cough was complained of by 38.8% of children with skin lesion compared to 3.1% of children with normal skin⁹. In another study in West Bengal, India 114 (3.7%) out of 6695 children below 11 years had evidences of arsenical skin disease. In Bangladesh, 298 (6.11%) out of 4877 children below 11 years were reported to have arsenical skin lesion due to drinking of arsenic contaminated

water.¹⁰ However, higher prevalence of skin lesion due to consumption of contaminated groundwater was observed by Watanabe and others among 241 children (age 4–15 yr) living in two rural villages in northern Bangladesh,. The arsenic concentrations of the tube well waters ranged from less than detection limit to 535 µg/L. Approximately half of the examined children exhibited dermatological symptoms with relatively obscured dose-response relationship; an observation suggesting that the children were no less susceptible to the dermatological effects of arsenic than the adults living in the same communities. Proportion of the children with lower BMI significantly increased with increasing arsenic exposure level and the dose-response relationship was consistently observed among the subgroups.¹¹

Prevalence of skin manifestations in children due to drinking of arsenic contaminated water was reported from epidemiological studies carried out in 1995-96 in South 24 Parganas, West Bengal, India. Pigmentation and keratosis were observed among boys and girls (age <9 yrs), who were exposed to arsenic above 50 µg/l, though less compared to adults. Nine (1.7%) out of 536 girls and

12(1.9%) out of 613 boys below the age of 9 years had pigmentation due to exposure of high level of arsenic in water. The number of subjects with keratosis were 1 (0.2%) and 3 (0.48%) in girls and boys respectively.² Baseline study conducted in the field area of the current study showed that over all prevalence of pigmentation and or keratosis was around 1.6% among participants having common source of exposure from school tube well and there was no change in prevalence of pigmentation and or keratosis in follow up survey. Majority cases of pigmentation and keratosis were mild. 15.8% and 13.64% of population had one or more dermatological and non dermatological manifestations of arsenicosis in the base line and follow up survey. So there was 1.94% decrease in prevalence and this decrease was mainly among the non dermatological manifestations. In participants although the skin manifestations like pigmentation and keratosis was not found to improve at the end of six months but non dermatological manifestations like chronic cough, weakness and dyspepsia was found to be reduced by 0.2% to 0.4% at the end of 6 months of intervention study indicating beneficial effect of safe water on skin lesions. Most important observation during the follow-up study was persistence of

dermatological manifestations and severe symptoms of chronic lung disease in spite of taking arsenic-safe water for 6 months. Around 70% of population was not aware about adverse health effects of arsenicosis. Although 40% of population was taking plenty of green leafy vegetables and seasonal fruits which are rich in anti oxidants but nearly 70% of population were not taking egg, fish, meat or any other animal protein regularly and in a study among arsenic exposed study population of south 24 Parganas it was found that deficiencies of some nutrients like animal protein, calcium, fiber, folate and vitamin C may increase the risk of arsenic induced skin lesions.¹²

Limited information is available in the literature regarding the long-term effect of chronic arsenic toxicity after stoppage of consumption of arsenic-containing water. To determine the effect of providing safe water to affected people, a cohort of 24 patients with chronic arsenicosis were re-examined after drinking arsenic-free water (<10 µg/l) for a period varying from 2 to 10 years by Guha Mazumder *et al.* in 1999.¹³ These people had been drinking arsenic-contaminated water (130-2000 µg/l) for 4-15 years. Weakness and anemia were present in 91.6% and 58.3% of cases initially and were persistent in 60.8% and 33% of cases, respectively, on repeat

examination. Partial improvement of pigmentation and keratosis were observed in 45% and 46% of patients, respectively. However, liver enlargement was persistent in 86% of cases. The most distressing observation was the new appearance of signs of chronic lung disease (cough, shortness of breath, and chest signs) in 41.6% of cases. There was a slight reduction of clinical symptoms of neuropathy. It was present in 45.8% of cases at the time of initial examination and in 33.8% of cases during the subsequent period ($P < 0.5$).¹³ Changes of severity of skin lesions over a period of 10 years were investigated amongst an affected cohort in an area having arsenic-contaminated shallow wells due to tin mining activities in Southern Thailand where interventions to reduce arsenic contaminated water had been implemented. Over 10-year period, both regression and progression of lesions occurred, though the majority of the subjects followed up remained the same. Drinking predominantly arsenic-free water increased the probability of regression in subjects with mild stage lesions but not in those with more advanced stage lesions. By contrast, a high arsenic content in the household well water, even though it was not used for drinking, decreased the probability of lesion regression among the subjects in more advanced stage but not among milder stage cases. Irrespective of

initial stage, a period of absence from the affected area increased the likelihood of lesion regression.⁷

Another cohort follow-up study was carried out by GuhaMazumder *et al.* (2003)¹⁴ on 1074 people (arsenic-exposed people-623, control population-451) in South 24 Parganas, West Bengal, 5 years after an original baseline clinical examination. Out of 199 people with skin lesion among the arsenic-exposed population who were consuming safe water during the last 5 years, the skin lesions cleared or decreased in 49.7% of people. However, new skin lesions appeared in 32 (10.5%) out of 306 people who were not diagnosed with such lesions previously.

In a study carried out in Inner Mongolia, China, Sun *et al.* (2006)¹⁵ reported that skin lesions improved to some extent after drinking low arsenic-containing water for 1 year. However, a 5-year follow-up study showed no more significant improvement of skin lesions, while the potential risk of arsenic-induced cancers after cutting off high arsenic exposure was still uncertain and indefinite. The current study, documented that arsenical skin lesions do not improve with intake of arsenic-safe water for 6 months. However, it needs to be mentioned that improvement in skin

score was noticed in other studies at least 5 to 10 years after intake of safe water thereby creating urgent need for further longitudinal follow up studies for longer duration. But in an endemic situation of ground water arsenic contamination of a country like West Bengal, the prevalence of arsenical skin lesions are mild (skin score 1-2) in majority (87.56%) of the cases.⁵ Hence, the main strategy for arsenic

mitigation program need to be addressed to ensure availability of arsenic-safe water in an arsenic-endemic region.

However, the prognosis of arsenicosis cases with severe skin lesion and major systemic disease like chronic lung disease are unsatisfactory, and fatality occurs due to severe lung disease and cancers, like lung cancer.

Conclusion and Recommendation

Around 11.36% of school children were having clinical features of suspected arsenicosis. Over all 15.8% and 13.64% of population had one or more dermatological and non dermatological manifestations of arsenicosis in the baseline and follow up survey. Intervention with arsenic-safe water was found to cause improvement of non dermatological of cases of arsenicosis. However, dermatological manifestations showed no improvement. But there is documentary evidence of improvement of skin manifestations following intake of safe water for 5 to 10 years indicating necessity for similar follow up studies for longer duration. The primary care providers of the local region can identify the problem early and can start prompt intervention to prevent development of future complication of chronic arsenic

toxicity like cancers and other systemic complications. Despite the magnitude of this potentially fatal toxicity, there is no effective therapy for this disease; patients once affected may not recover. Moreover 70% of the study population were not aware about adverse health effects of arsenicosis. Only cessation of exposure to drinking water or items of elevated concentration of arsenic was believed to provide effective remedy. So, primary prevention by raising levels of awareness among primary care providers of the local region about signs and symptoms of arsenicosis and available intervention will definitely help to mitigate this important public health problem.

It is, therefore, an urgent need to make arrangement for availability of safe water

source among the arsenic-affected people in the district. Many of the people in the affected villages are not aware of contamination of their home tube wells with arsenic. Awareness generation and motivation of the people for testing their drinking water sources for arsenic and environmental interventions like rain water harvesting, ground water recharge, and restricting excessive use of ground water for domestic and agricultural purposes are also important to prevent further exposure of arsenic to these people.

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Further, arsenic-affected people with severe skin lesions and systemic manifestations like lung disease, neuropathy etc. are having unbearable suffering. These people are very poor and live in distant villages where hospital facilities are not easily available. Arrangement for free treatment of these patients in state referral hospitals and free transport facility from their villages could help a lot in alleviating the suffering of these people

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