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CORRELATION BETWEEN BODY MASS INDEX AND SERUM CALCIUM WITH URINARY FLUORIDE LEVEL IN FLUOROSIS ENDEMIC AREA OF BANKURA: A CROSS-SECTIONAL STUDY

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ABSTRACT

A cross-sectional field based study was under taken in the fluorosis endemic area of village Machatora within Simlapal block in Bankura district, West Bengal to find out whether there was any correlation between body mass index (BMI) and serum calcium with urinary fluoride level among the chronic endemic fluorosis cases. The range of the ground water fluoride level was 0.39-12.69 mg/L with the mean of 3.3. Out of 50 cases, 32 samples (64%) showed high urinary fluoride level (> 1.5mg/L), 12 samples (24%) showed low serum calcium and 9 samples (18%) showed BMI > 29 in comparison to the control group.

INTRODUCTION

Chronic endemic fluorosis is caused by an excessive ingestion of fluoride through drinking water and foods staffs [1, 2, 4]. In India, an upper limit of fluoride in portable drinking water is 1.5 mg/L (BIS / WHO) [6].The fluoride level in drinking water varies region to region. Fluorosis is continued to be an endemic problems in Machatora village, Simlapal block, Bankura district, West Bengal, India [7]. Fluorosis has already affected more than 15 states in India and West Bengal is one of the victims [6]. Among others, Bankura is one of the worst affected districts in West Bengal. Peoples residing in this area are compelled to accept high concentration of fluoride through drinking water and foods staffs [7]. Geological survey of India have clearly indicated the presence of rocks in Bankura, which are rich in fluoride, namely rock phosphate, apatite, phosphorites etc. are the source of fluoride in ground water [2, 4, 5]. During rain fall, fluoride leaches out from the crust and contaminating the water source and agricultural fields. Though previously fluorosis was thought to be a disease of teeth and skeletal system, it actually affects multiple systems [4]. Due to strong electronegative nature, fluoride ions interact with positively charged Ca^{2+} especially in teeth and bones and can act as a cumulative toxin which alters bone-resorption, bone minerals metabolism, producing different skeletal diseases [10, 12, 13].

MATERIALS AND METHODS

After getting approval of Institutional Ethical committee of Bankura Sammilani Medical College and Hospital, 50 individuals (28 males and 22 females of age group 32.5 + 9 years with mean 39.2 years) were selected by simple random sampling method as cases from Machatora village which is a fluorosis endemic area of Bankura district. Age and sex matched 25 individuals who were from non-endemic areas of fluorosis and having same type of drinking water source (ground water), were selected as control. The person having diabetes, hypothyroidism, menopause and documented metabolic bone disorders were excluded from the study. The clinical diagnosis of endemic fluorosis was modified from the criteria of Wang et al. [9, 14]

(I) Living in the endemic fluorosis region since birth

(II) Consuming water with high fluoride level (> 1.5mg/L).

After taking informed consents from the patients or their legal guardians, urine and blood samples were collected from the study and control population. Height, weight and other physical parameters were recorded during clinical examination of the subjects according to a predesigned, pretested case report form. Body mass index (BMI) was calculated for each person by the formula: BMI = weight / height^2 …. [height was in meter and weight in kg]. Three to four mL of fasting venous blood were collected without using tourniquet from each subject in separate plain vials for serum calcium estimation by standard biochemical procedure. Drinking water and spot urine samples were collected in sterile, plastic container for estimation of fluoride by Ion Specific Electrode (ORION 9609BNWF).

Data were codified in excel spread sheet and analyzed by software based process (Statistical Package for the Social Sciences inc., Chicago, Illinois, USA, Ver.20) using 2-tailed Spearman's correlation and the significance of correlation was calculated at 95% confidence interval and considered statistically significant when the value was < 0.05 and highly significant when significance was <0.001.

RESULTS

Mean fluoride content in drinking water sources of study groups were higher, mean serum calcium level were low and urinary fluoride (UF) levels were significantly higher than control group. A positive correlation existed between drinking water fluoride and UF.

Table: 1- DIFFERENT PARAMETERS IN STUDY GROUPS AND CONTROL:

Groups	Range of F in water (mg/L)	Mean F in water (mg/L) Mean ± SD	F in urine (mg/L) Mean ± SD	Serum Ca (mg/dL) Mean ± SD	BMI Mean ± SD
Control (n=25)	0.01 – 0.99	0.711 ± 0.214	0.562 ± 0.218	9.584 ± 0.443	26.64 ± 2.04
S1 (n=20)	1.00 – 3.99	2.143 ± 0.734	1.818 ± 0.318	8.930 ± 0.377	27.15 ± 1.27
S2 (n=20)	4.00 – 7.99	5.158 ± 1.077	2.456 ± 0.253	8.450 ± 0.411	27.70 ± 1.69
S3 (n=10)	8.00 –11.99	9.740 ± 1.274	2.998 ± 0.199	7.860 ± 0.775	27.60 ± 1.35

S1, S2, S3 were study populations divided according to the range of fluoride concentration in drinking water.

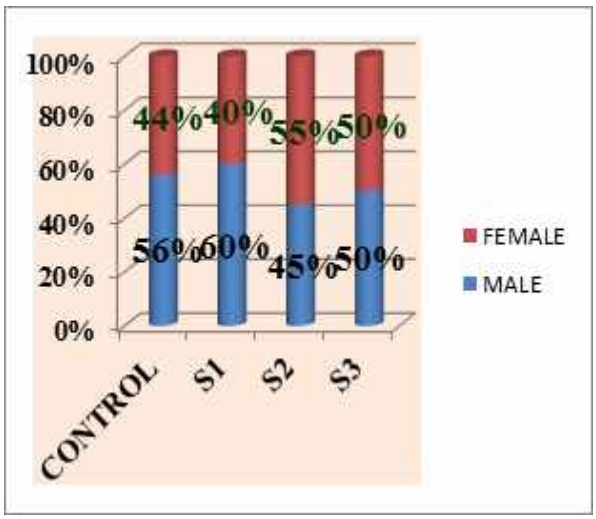
It's obvious that increment of fluoride concentration in water and urine, drastically reduced serum calcium in study populations and Fluoride in water and urine in all groups were also significantly related.

In control group, serum calcium and fluoride in water showed inverse significant relationship (rho= -0.567 and significance= 0.003). In S1 population, serum calcium had no significant relationship with fluoride in water or urine. In S2 population, there was a highly significant inverse relationship in between serum calcium and fluoride in water (rho= -0.845 and significance=

<0.001). S3 population (exposed to highest fluoride concentration in drinking water) showed more strong significant inverse relationship between serum calcium and fluoride in water (rho= -0.976 and significance= <0.001). So increment of fluoride in water and urine significantly depleted serum calcium.

BMI was not related significantly to calcium or fluoride levels in any groups except in S1, where serum calcium inversely and significantly related to BMI (rho= -0.638 and significance= 0.002). Though the absolute number of male were more than female, the gender ratio of affected people was tends to be 1:1, where water fluoride level is high. So fluorosis had no predilection to any sex.

Figure- 1: DISTRIBUTION OF POPULATION ACCORDING TO GENDER IN DIFFERENT GROUPS:



DISCUSSION

Ingestion of fluoride through drinking water and foods are absorbed by the stomach and small intestine through passive diffusion depending on physical and chemical nature of fluoride. At least 95% of the 2.6 g of total body fluoride is located in bones and teeth. ~90% of excess fluoride is excreted in urine [11].
Hydro-geochemical investigations showed that Bankura was one of the severely affected districts with fluoride. It was also revealed that fluoride rich groundwater was also rich in high iron as under the prevailing pH iron combines to fluorine to form $FeF6^{3+}$, FeF^{2+} and FeF_2^{+}.

Different studies showed that high fluoride content in the sub-surface water in Bankura ultimately leads to cause skeletal disorders, dental problems, goiter and even some malignancies. Yellow cracked teeth, joint pains, crippled limbs, quick ageing are usual symptoms due to chronic exposure to high fluoride content in the fluorosis endemic areas. Knee osteoarthritis is a very common manifestation in skeletal fluorosis which is readily diagnosed radiologically by presence of osteophytic lesions at joints.

Fluoride, a micronutrient, functions as a double edged sword in body. Within recommended reference range (maximum limit of fluoride intake in a day 10mg [8]), fluoride reduces of tooth decay [11] and helps in dentition but increased consumption produces endotoxicosis. Fluoride can be exchanged for hydroxyl ion in the crystal structure of apatite, one main component of bone and teeth. This stabilizes the regenerating tooth surface [11]. Due to strong electro negative nature, fluoride is attracted by divalent positively charged calcium ions in teeth and bones.

High fluoride ingestion has definite relationship with increased calcitonin concentration and thus causes hypocalcemia by inhibiting osteoclastic activity, increasing osteoblastic action, helping in mineralization of matrix due to Gla-dependent binding of calcium and subsequent absorption of hydroxyapetite in bone and inhibiting renal tubular absorption of calcium and phosphate, which ultimately increases parathyroid function to achieve calcium homeostasis and hence, secondary parathyroidism with glandular hyperplasia occurs. Parathyroid hormone (PTH) is a polypeptide composed of 84 amino acids and it functions as a mediator of bone modelling and calcium homeostasis. Raised parathormone activates osteoclasts and thus bone resorption *in-vivo* which mobilizes calcium from bone and thus may manifest untoward symptoms of skeletal fluorosis. Moreover, fluoride can alter resorption of bone by its cumulative toxicity and impair bone collagen synthesis.

Fluoride induces net increase in bone formation and decreases calcium absorption from GI tract beyond the degree expected by formation of Calcium fluoride complexes. Both this phenomena increase the demand of calcium in body. In dietary insufficiency of calcium the condition is further worsen and is detrimental for the bones.

In plasma, fluoride is transported as ionic and non-ionic form. Ionic fluoride does not bind to plasma proteins and is easily excreted through kidney, the primary organ of excretion for fluorides. Amount of urinary fluoride reflects the amount of fluoride ingested. It has been documented that the urinary excretion of fluoride is 32–80% of total fluoride intake. Present study revealed that there was a significant correlation between fluoride in water and urinary fluoride which was corroborative with the theory as well.

CONCLUSION:

Increased chronic consumption of fluoride from sub-surface water source significantly reduces serum calcium level and thus skeletal fluorosis sets in. Mild high level of fluoride in drinking water (1.00 - 3.99 mg/dL) showed inverse significant relationship between BMI and serum calcium.

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