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Some Observations on Fluoride Toxicity

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Abstract

The factors which govern the development of fluoride toxicity are the prevalence of high levels of fluoride in water and food stuffs, duration of their exposure, hard manual labour, nutritional status and nature of the renal function. All the above known factors do not explain the disparities in the incidence of fluorosis and also the variable reports of fluoride toxicity with regard to different organs. An effort was made to study the role of trace elements in fluoride toxicity in the endemic region. Even though no definite conclusions can be drawn from the study, the role of certain elements in aggravating or lessening the fluoride toxicity seems to suggest that further metabolic studies may be rewarding.

Key words -

Fluoride intoxication,
Myopathy due to fluorosis,
Sural nerve and muscle biopsies in fluorosis,
Role of trace elements in fluorosis

A study of fluoride metabolism has become increasingly necessary in view of the widespread prevalence of fluorosis in our country and its likely occurrence in western countries, since the fluoridation of water supplies has been undertaken as a check and also to reduce dental decay and caries. Recent studies of dietary fluoride content in fluoridated water supplied areas indicated that the daily fluoride intake of food was three to five times that of nonfluoridated areas and overall intake of fluoride in these areas was more than what was anticipated [2], [6], [15] and this may lead to development of skeletal fluorosis in individuals, especially in those with impaired renal function [11], [14].

Biological effects of fluoride intoxication are related to the total amount of fluoride ingested, whatever the source be it food, water or air [3], [10], [29]. The factors which govern the development of skeletal flurosis are

(a) the prevalence of high levels of fluoride intake;
(b) continued exposure to fluoride;
(c) strenous manual labour;
(d) poor nutrition; and
(e) impaired renal function due to disease.

In regions having very high fluoride content the disease may even affect younger age groups including children. Obviously the longer the exposure to fluoride the higher will be its incidence. It is farm labourers engaged in manual work who are prone to fluorosis rather than those belonging to sedantary occupations. Some constituents of water accounting for its hardness or alkalinity also seem to promote the incidence of fluorosis by affecting the amount of fluoride absorbed from the gut [7], [10], [18]. Epidemilogical observations show that nutritional status has a bearing on

chronic fluoride toxicity and that the diets having low level of calcium and vitamin 'C' accentuate it [24]. The single and most important factor which throws light on the development of fluoride toxicity is the status of the kidney. Individuals with normal functioning kidneys can excrete large amounts of fluorides without significant retention in the body. But the excretation of fluoride is much less if the person concerned is suffering from chronic kidney disease in which case he may develop fluorosis even if the water consumed contains low levels of fluoride [11], [14].

Even after considering all the above known factors one cannot explain why disparities in the incidence of fluorosis, often wide, occur. On the one hand, some reports have mentioned the development of neurological complications of fluorosis when the fluoride content of drinking water is only 1.2 to 1.35 P PM which is considered, to be safe in many countries [26]. On the other hand, there are people consuming water containing as much as 10 and even 15 P PM of fluoride who have never developed any such sequelae. Similarly, there are strong variations in the incidence of fluoride toxicity with regard to other organs like muscle, myocardium, spinal cord and optic pathways [28]. For instance, Okushi [27] and Takamore [27] from Japan reported a high incidence of myocardial damage in the endemic fluorosis area of Aso-volcanic district containing 6-13 P PM of fluoride. They found depressed ST, inverted T, prolonged QT internal, bundle branch block, pulmonary P, enlargement of heart in those people and also in experimental animals. But this is not borne out by the experimental animals. But this is not borne out by the experience of workers from our country [21]. We have studied in detail 100 individuals 10 to 65 years of age belonging to Yedavalli village having one of the highest fluoride levels in drinking water in India. Our observations show that the repolarisation abnormalities have not occurred and that the correlated QT intervals were well within the normal range of 0.30 - 0.42 seconds. The only E.C.G. abnormality noticed was in a boy of twelve with a trial septal defect. However our survey of Nabai - a village in the fluoride belt of Nalgonda District in Andhra Pradesh revealed an unusually high incidence of optic atrophy [20]. But there has been no such high incidence of optic atrophy in areas like Kammaguda, Yadavalli and Yellareddyguda having even higher fluoride levels in drinking water.

Similarly the reports of Kaul and Susheela [12] and Franke [8] indicate that myopathy occurs in human fluorosis as well as in experimental animals, although the experimental model used by the former is not comparable to human fluorosis cases. Our electro-myographic studies in endemic skeletal fluorosis provided unequivocal evidence of neurogenic atrophy and there was no suggestion of myopathy [25]. The nerve condition was not affected in fluorosis unless peripheral nerves were compressed by exostotic spurs in the limbs. Biopsies of skeletal muscle performed by us in cases of human fluorosis studied histochemically and histologically exhibited evidence of denervation but dystrophic changes were absent [13]. Our sural nerve biopsies revealed reduction in mean fibre densities of myelinated fibres and there was a decrease in the number of fibres of small size [19].

There was poor correlation between internodal lengths and internal diameters suggesting a process of demyelination and remyelination. There was also evidence of axonal damage. Franke [8] noticed in a case of industrial fluorosis evidence of myelopathy and anterior horn cell disease but this was not borne out by our studies in fluorotic dogs [23].

It is known that magnesium has a peculiar relationship with fluoride and fluoride toxicity can be reduced or alleviated by magnesium administration [15], [22]. Similarly, aluminium and boron are useful as antidotes in acute fluoride intoxication [1], [3], [4] Selenium is known to aggravate fluoride toxicity [9] and not much is known about the role of other trace elements. So it was decided to study the content of various trace elements in normal, low endemic and hyperendemic areas of fluorosis to see whether the content of these elements would explain the variation in the incidence of fluoride toxicity. For this study three villages from the fluorosis belt of Nalgonda district of Andhra Pradesh, namely, Naibai, Yellareddyguda and Yedavalli have been selected. All these villages are close to one another and naturally climatic conditions, types of foods that are available and diatetic habits of the people are similar.

Material and Methods

Water samples of the villages - Naibai and Yellareddyguda were analysed by emission spectographic method for the presence of trace elements. 50 ul.sample of well water commonly used by inhabitants of these villages were loaded on to the electrode and 50 ml. of the sample was evaporated to 2 ml. and 50

ul. of the concentrated solution was loaded on to electrode. The presence of 25 elements and their approximate concentration was found by screening method. Since the estimation of all these elements in food stuffs and well water in detail was difficult, it was decided to estimate in detail the content of five elements namely Ca, Mg, F, As and Cd in the various food stuffs eaten in these two villages and another village Yedavalli: the normal levels of these elements in water and food stuffs in non-endemic areas are available from reports of the National Institute of Nutrition and Institute of Preventive Medicine in Hyderabad for comparison.

The incidence of dental and skeletal fluorosis, fluoride level of well waters of these villages and other characteristics were also studied.

Next diet charts were made for the adult manual labourers residing in these villages consuming about 3000 calories a day, Estimates of 5 elements was recorded based on the dietic habits of these people and the content of these elements in food stuffs such as rice, wheat, vegetables and pulses.

Results & Discussion

The incidence of fluorosis and fluoride levels of well waters and other characteristics of this water are shown in Table-I. The scrutiny of the above table reveals that Naibai village has lower fluoride levels, lower incidence of skeletal fluorosis as compared to other villages but it has higher incidence of optic atrophy as revealed by our earlier study. pH, alkanity and hardness of water, though varying from village to village, do not seem to be much different from what they are in other villages of the non endemic region. Results of analysis of water samples are shown in Table II and III and those of food stuffs in Table IV. It is pertinent to note that water sample analysis done by emission spectrographic method is a semiquantitative one which is the reason why the results are expressed a supper limbs. However, it is significant that concentrations of arsenic, aluminium and boron are very high in Naibai as compared to the other two villages. The very high levels of arsenic found in water samples studies by spectrographic method may explain the high incidence of optic atrophy seen in Naibai but this is not borne out by the study of water samples by specific ion electrode method. As far as the levels of elements in food stuffs are concerned, those of aluminium and boron, etc. are high in Naibai and constantly so in estimation made by both the methods which might explain the relatively low incidence of skeletal fluorosis in this village as compared to other two villages - even though fluoride levels are higher in the latter, though not too high.

Table I - Incidence of fluorosis and fluoride levels of well waters

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Table II - Results of the emission spectrographic analysis of water samples (Values are expressed in ppm)

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Table III - Results of analysis of water samples

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Table IV - Results of analysis of food stuffs

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Note: (1) S.N.S. -Sample not sufficient for analysis, after processing.
(2) Sample No.40 became semi-solid on processing. Hence could not be taken up for analysis.

Table V - Amounts of trace elements in daily diet which consisted of 450 grams of rice, 110 grams of pulses 200 gms of Jowar, 200 gms of Vegetables, 20 gms of oil and 1200 ml. of water

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As for the estimations of amounts of trace elements in diets which are shown in table V, one has to consider that there are so many other variables like content of these elements in water samples in different seasons, quantity of water drunk by individuals, individual consumption of food stuffs etc. It is also important to note that the residents of Naibai are ingesting larger amounts of fluoride through their food though the water levels of fluoride is low. It is also known that trace elements of toxicity are related to individual idiosyncracy rather than to the amount of the element consumed. When this information was fed to a computer and the differences in the amounts consumed by individuals of various villages over a period of decades calculated, the differences in concentrations of these various elements may become meaningful. But the relationship to and the effect of trace elements on fluoride toxicity and difficult to establish as they occur in all kind of foods and water and that they exert activity in concentration relatively low into those of major mineral elements. There is no single maximum toxic level for these elements because the toxicity of any particular element can be greatly influenced by the presence of other trace elements. For example selenium toxicity can be reduced by administering As [9]. Similarly, cadmium has relationship to zinc [5]. In acute fluoride toxicity cases administration of aluminium and boron are helpful and their high levels may lessen fluoride toxicity [1], [4]. Selenium does aggravate fluoride toxicity and cadmium is known to produce pathological lesions of CNS and all these elements are present in waters and food stuffs. However, a detailed metabolic study of some of these elements is worth undertaking for explaining the variable incidence of fluoride toxicity.

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