STUDIES ON FLUORIDE-ALUMINUM COMBINED TOXICOSIS

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1. Environmental Sanitation and Epidemiology

In the Shuicheng area of Guizhou Province more than 1500 people were examined and screened for F-Al combined toxicosis. Blood and urine from patients and normal youths in the endemic area were collected and assayed for F and Al. X-ray pictures of the two groups were taken and analyzed, and an investigation of the environment was also conducted.

The results revealed that the patients belonged to families in which corn dried by burning coal mixed with kaolin was eaten. Among the people examined, 50 had osteomalacia, corresponding to an incidence of 3.95%. For the youths who were less than 20 years old, the morbidity was 6.13%.

The Al and F contents in the blood and urine of the patients were significantly higher than those of the control group. Al levels in blood and urine of sick children were significantly higher than those of normal children in the toxicosis area where the grain dried by burning the coal mixture absorbed large amounts of aluminum.

Biochemical tests on 84 patients and 47 normal people disclosed that the levels of lactic dehydrogenase (LDH) and creatine phosphate kinase (CPK) activities as well as the contents of Cu and P were increased (p < 0.001), but the alkaline phosphatase (ALP) level decreased.

The level of lipoxygenase (LPO) and antioxidation were measured on 12 sick children and 21 normal children in the toxicosis area as well as on 11 normal children in the control area. Glutathione peroxidase (GSH-Px) activity in the plasma of children in the toxicosis area was decreased. There were no significant differences between the toxicosis and control groups for plasma superoxide dismutase (SOD) activity, LPO content, GSH level, and red blood cell count (RBC).

The intelligence of 196 children (6.5-12 years old) was measured by a drawing test. It was found that the mean intelligence score of children in the toxicosis area was clearly lower than that of children in the control area.

F and Al levels in blood and urine from 100 osteomalacia patients in endemic areas of Guizhou and Hebei were also determined and were found to be significantly higher than in those of controls. Thus F-Al combined toxicosis is endemic in the severe fluorosis areas.
X-rays of 150 persons in the endemic areas were taken. The prevalence of abnormal radiology was 65%.

Elemental analysis of blood and urine from 68 youths in the endemic area revealed changes of Zn, Mo, Mn, and Fe levels were related to the levels of Ca, P, Mg, and Cu. For example, there was a negative relationship between Zn and Mo in the patient group, but a positive relationship between Zn and Mo in the control group.

2. Animal Toxicology

In experiments with male chickens, F and Al contents in the biomaterial were determined, and structural changes in the bones were assayed by a histomorphometric method with tetracycline as a tissue marker. A synergism was found between F and Al when the ratio of F and Al in diet was 2:1, but independent action was found when the ratio was 1:1.

In experiments with rabbits, Al-F combined toxicosis was related to the chemical forms of aluminum as well as F and could accelerate accumulation in bone. The accumulation of Al in bone from organic Al in food was accelerated by F in the diet, but inorganic Al in the diet had an antagonistic effect against F.

In experiments with rats, it was confirmed that F can increase Al absorption and accumulation. It was also found that dental fluorosis and damage to kidney function were related to F-Al combined toxicosis. These results indicated that Al has a contributing relationship to fluorosis.

Based on the foregoing experiments, therapeutic experiments with Al-F intoxicated rats were carried out. Boron and silicon reduced blood F levels in the control and Al groups. Boron, silicon, and zeolite significantly decreased bone Al, which therefore might have therapeutic value.

3. Clinical treatment and prevention

To cut off sources of F and Al intake, it is necessary for people not to do direct drying of food or grain by burning coal or coal mixed with kaolin. In order to set up models, the stoves of 70 families were improved with proper ventilation. Operations were also performed on three patients with osteomalacia. In the clinical work, health education was provided in many ways. A comprehensive plan for prevention and treatment based on decreasing total F and Al intake was prepared and submitted to the Government for approval.

Key words: Aluminium; Fluoride; Combined toxicosis.

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THE CARTILAGE DAMAGE OF FLUOROSIS

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A study of 260 cases of skeletal fluorosis demonstrated that the large joints of the extremities were severely damaged, especially the elbow, which was involved in 93% of the cases. In order to determine whether fluorosis damages cartilage, 20 young rabbits, and 10 young dogs were fed with sodium fluoride 20 mg/kg/day for periods up to 6 months. Radiographs and correlated HE-stained sections of the large joints of the extremities were made. Electromicroscopic examinations were also made of cartilage specimens of 5 young dogs.

Histologic study showed irregular calcareous deposits and globules in the matrix of the articular and epiphyseal cartilage. In the epiphyseal cartilage the way these were concentrated demonstrated that the disturbance occurred in the course of epiphyseal cartilage calcification. We also saw multiple dry necroses in the articular cartilage.

Electromicroscopic examination showed chondrocyte deformations, with cellular processes shortened or disappeared, calcareous deposits within the cytoplasm, increased glycogen deposition which almost filled the cell body, with organelles disappeared and myelin appearing in the cell. All the above changes indicate necrosis of the cell, demonstrating the direct damage to chondrocytes which is the origin of the damage to cartilage caused by fluorosis. We suggest that this pathologic change be called the “arthropathy of fluorosis.”

The radiographic changes of this arthropathy of fluorosis include: cyst formation, sclerosis of subarticular cartilage, and narrowing of the joint space, similar to general degenerative arthropathy. But the calcification and ossification of tendons and ligaments around the joints, and of synovia and ligaments within the joints, are characteristic changes of fluorosis and are rarely seen in degenerative arthropathy.

Key words: Arthropathy; Cartilage; Chondrocytes; Fluorosis.  
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SERUM AND URINARY FLUORIDE CONCENTRATION
IN FLUORIDE-EXPOSED WORKERS OF AN
ALUMINIUM SMELTING FACTORY IN CHINA

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Measuring the fluoride (F) concentration of post-shift serum and urine is considered to be an appropriate way to evaluate F exposure in the work environment.

To define the relationship between F concentrations in the serum and urine of workers and the amount of gaseous F in the workplace, post-shift serum and urine samples of 200 F-exposed workers and 121 unexposed workers of an aluminium smelting factory were examined. For the measurement of gaseous F concentration in the air a volumetric method was used.

Average gaseous F concentration in each work environment was 1.89 mg/m³. Although serum F concentrations in unexposed workers increased with age, those in F-exposed workers did not change, and the levels of F in their serum and urine were more than twice as high as those in the control. The serum and urinary F of exposed workers were well correlated (r = +0.66).

From the present results the environmental exposure to gaseous F in an aluminium smelting factory could be monitored by determining the post-shift serum and urinary F concentrations.

Key words: Fluoride exposed workers; Serum fluoride; Urinary fluoride.

FLUORIDE METABOLISM AND KIDNEY FUNCTION:
HEALTH CARE OF FLUORIDE EXPOSED WORKERS

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The major pathway for fluoride (F) elimination from the human body is via the kidney. F concentration in urine has, therefore, been recognized as a good indicator of F body burden. When the renal function deteriorates, the ability to excrete F markedly decreases, possibly resulting in greater retention of F in the body.

In this study, the usefulness of measuring F concentration in serum, urine and hair, as indicators for health care of hydrofluoric acid (HF) workers, especially for persons with diminished kidney function, was investigated. F concentrations were measured in serum, urine and hair specimens of patients with chronic renal failure (CRF), HF workers and nonexposed healthy controls.

Post-shift serum, urinary and hair F concentrations in HF workers were higher (P < 0.001) than the control subjects. Although the serum and hair concentrations of patients with CRF were markedly higher (P < 0.001) than controls, their urinary contents of F remained normal. Serum F concentrations in HF workers with diminished renal function were strikingly higher than in other patients with CRF and HF workers. Their urinary levels of F, however, were within normal limits.

In conclusion, the monitoring of serum and hair F, and renal function tests other than urine analysis are necessary for the health care of F exposed persons, especially for those with impaired renal function.

Key words: Fluoride exposed workers; Fluoride metabolism; Kidney function.
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PLANNING, IMPLEMENTATION AND EVALUATION
OF A FLUOROSIS CONTROL PROJECT
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Excess fluoride in drinking water results in a progressive, crippling, irreversible, untreated health problem: fluorosis. The fluorosis problem has been reported in fifteen states of India.

Prevention is the only hope for control of this dreaded disease. The only way to prevent this disease is to provide water with a permissible level of fluoride forever. Planning, implementation and evaluation of such a water supply project should be based on sound epidemiological observations, and cost benefit and cost effective analyses.

Such a study was conducted in Mehsana district of Gujarat state, to tackle the problem of fluorosis in 550 villages. Two alternative technologies, surface water supply and defluoridation plants (Nalgonda technique), were evaluated. The results justified the need for such a fluorosis control programme, and strongly supported the surface water supply scheme for overall economic and health benefits.

Key words: Defluoridation; Fluorosis control and prevention; Surface water.
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DEFLUORIDATION OF DRINKING WATER
BY CO-PRECIPITATION WITH APATITE
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Dental fluorosis is a major problem in some rural areas of China and other countries, where small flowthrough home water treatment units may be used to reduce the fluoride (F) concentration in drinking water to acceptable limits. However, such a system is often difficult to arrange where there is no piped water supply, gradual exhaustion of the absorbent agent is not easily detected, and bacterial contamination is possible. To overcome these problems a batch defluoridation method based on the precipitation of F as fluorapatite is now under development. In this two-step technique water is first saturated with the calcium phosphate mineral brushite, and subsequent seeding with a less-soluble calcium phosphate, hydroxyapatite, causes precipitation of fluorapatite. The method has been tested with water in the range 1-10 ppm F. Each cycle of the procedure can reduce the F concentration approx 2.5 ppm, and cycle effects are additive. Addition of calcium hydroxide during the brushite step improves F removal but results in a high residual pH. Computer simulations of the fluorapatite precipitation process suggest that any desired reduction in F may be achieved by adding sufficient calcium and phosphate and/or by raising the pH. Co-precipitation in a batch system promises to be a convenient low-technology method to defluoridate drinking water.

Key words: Apatite; Coprecipitation; Defluoridation.
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