BIOLOGICAL MONITORING OF FLUORIDE-EXPOSED WORKERS
ESPECIALLY FOR HEALTH CARE OF ELDERLY WORKERS

Koichi Kono
Osaka, Japan

The occupational health control of workers being exposed to fluoride (F) has focused on the measurement of the environmental F at the workplace and on medical surveillance of the workers, particularly the biological monitoring of exposed workers.

The major pathway for F elimination from the human body is via the kidney. F concentration in urine has therefore been recognized as a good indicator of occupational F exposure. Compared with urinary F, serum F has not been fully evaluated as an indicator of F exposure because collecting the serum and measuring F concentration is often much more difficult than in the case of urine. It has recently been suggested that human hair is also a reliable index of chronic exposure to environmental toxins. The advantages of using hair as a biological indicator for occupational F exposure are that it is readily obtained and it is an easy matrix to use, since the concentration of F and other elements in the hair are much higher than those in biological fluids.

On the other hand, when renal function deteriorates, the ability to excrete F markedly decreases, possibly resulting in greater retention of F. Some investigators demonstrated that F concentrations in plasma and bone significantly increased in uremic patients. It has been shown that many aspects of kidney function decrease with age. F metabolism in elderly persons, however, remains incompletely understood. This paper deals with the usefulness of urine, serum and hair specimens as biological indicators for occupational exposure to F, and with the characteristics of the aging process related to renal function and F metabolism, especially for the health care of elderly workers exposed to hydrofluoric acid (HF).

For the determination of serum, urinary and hair F, the specimens from 142 healthy HF workers (aged 18 to 59) who had been engaged in washing glass bulbs for TV picture tubes and etching semiconductors were studied. These types of work were carried out continuously in a closed room in which HF was vaporized from several places. Therefore, HF concentrations in these places were generally constant, and ranged from 0.3 to 5.0 ppm. Pre- and post-shift serum and urine samples were taken on either Thursday or Friday. In those specimens the levels of F were expected to be the highest. A few milligrams of hair samples (ca, 5 cm in length) were cut close to the scalp in the occipital region of the subjects. External contamination of the hair among workers at the work place was minimized by having them wear protective caps during their shifts. As a control group, 270 unexposed workers, aged 18 to 59, who had been engaged in the assembling of TV picture tubes in the same factory, were examined. To investigate the influences of external contamination on hair analysis, the 20 hair samples from healthy male subjects (aged 20 to 40), where the concentrations of elements were measured before the experiment, were kept for one week at the work places. After that procedure, F and other elements in the hair were determined before and after washing the specimens.
In the second part of the study, 2-hour renal clearance determinations were performed on 97 healthy individuals (aged 35 to 69) living in a rural area of Japan. Fasting blood samples and urine specimens were taken from the subjects between 6.00 and 8.00 am.

In the third part of the study, seven patients with chronic renal failure (aged 40 to 78) and 11 healthy subjects (aged 20 to 57) were selected. The primary renal diseases of the patients were glomerulonephritis and pyelonephritis. After an overnight fasting, the subjects were given green tea which contains a high amount of F. Blood samples and 24-hour urine specimens were collected.

Serum and urinary F were measured using a F electrode method (Orion EA 940). The hair samples collected were washed with distilled water for 10 minutes, followed by acetone for 10 minutes. The X-ray fluorescence (XRF) spectrometer used was wavelength dispersive, simultaneous multi-element analyzer (Rigaku Symultex 2530) where F, Na, Mg, Al, K, P, Ca, Ni, Zn and I in the hair were measured.

The post-shift serum and urinary F concentrations in HF workers were significantly higher (p < 0.01) than the pre-shift concentrations. A mean F concentration of 82.3 μg/L in serum and 4 mg/L in urine with a lower fiducial limit (95%, p = 0.05) of 59.7 μg/L in serum and 2 mg/L in urine were estimated to correspond to an atmospheric HF concentration of 3 ppm, which is the maximum allowable environmental concentration recommended by the Japanese Association of Industrial Health (1964), and it is also the threshold limit value suggested by the American Conference of Governmental Industrial Hygienists (1967). With the exception of K and Fe values, the levels of F and other elements measured in the hair of HF workers were higher than those in the control subjects. The concentrations of F in hair and in post-shift urine were in good correlation. However, the correlation coefficient was low for F in hair and in serum. A high correlation coefficient was obtained between F and Ca, F and Mg, F and P, F and Na, and F and Al in HF workers. These relationships were not found in the control subjects. F concentrations markedly increased after the hair samples were retained in the work environment. However, it decreased to the reference value after the washing treatment. Ca, Mg, Al and other elements did not change throughout the experiments. The results of hair analysis in HF workers and the experiments support the hypothesis that Ca, Mg, Al and some other elements are shifted and efficiently excreted into the hair with F after long-term exposure to F.

There was a significant reduction in creatinine clearance (CCr) and F clearance (CF) with age. The amount of F filtered through the glomeruli per minute and tubular reabsorption of F seemed to remain unchanged until age 70. Twenty-four hour excretion of F and renal F clearance were well correlated (r = 0.87) in the healthy subjects. The ability to excrete F during 24 hours diminished 20 to 30% after age 50.

From the results obtained, it is suggested that occupational exposure to F can be monitored by determining the post-shift serum, urinary and hair F concentrations. For the health care of F exposed workers, aging is an important factor to be considered and it may not be adequate to measure only the urinary F concentra-
tion. The careful and frequent monitoring of serum, urinary and hair F as well as kidney function analysis appears to be necessary for the health care of F exposed workers, particularly for elderly workers with kidney hypofunction.

References (papers by K Kono et al)


Elemental analysis of hair among hydrofluoric acid exposed workers. *International Archives of Occupational and Environmental Health* 62 85-88 1990.

Serum fluoride as an indicator of occupational hydrofluoric acid exposure. *International Archives of Occupational and Environmental Health* 64 343-346 1992.

Urine, serum and hair monitoring of hydrofluoric acid workers. *International Archives of Occupational and Environmental Health* 65 S95-S98 1993.


Key words: Biological monitoring; Hair; Occupational fluorosis; Serum; Urine.

Address: Department of Hygiene and Public Health, Osaka Medical College, 2-7 Daigakumachi, Takatsuki City, Osaka 569, Japan.

---

**DIALYZABILITY OF FLUORIDE IN HEMODIALYSIS PATIENTS**

K Usuda, K Kono, M Watanabe, Y Takahashi, Y Yoshida, M Shimahara,* N Hashiguchi* and J Senda*

Osaka, Japan

Serum and dialysate fluoride (F) concentrations were measured in 29 patients who had undergone regular hemodialysis (HD) treatment. Serum concentrations of creatinine (Cr), blood urea nitrogen (BUN) and phosphorus (P) were also examined before and after HD in 92 patients including the above 29 under the same treatment. The dialysis clearances of these elements were estimated to evaluate the HD effect on serum F.

The dialysis clearances were: F 55.6 ± 101.3 mL/min, Cr 113.9 ± 29.3 mL/min, BUN 129.9 ± 25.7 mL/min and P 87.2 ± 32.6 mL/min. Based on our results, a notable dialyzability of F was confirmed, although the dialysis clearance of F was statistically lower than those for the other chemicals.

This study emphasized that, to prevent F-induced bone mineral disturbances in patients undergoing HD, it is important to control excessive F intake from work and community environments, in addition to improving the dialysis membrane.

Key words: Bone; Hemodialysis; Serum.

Address: Department of Hygiene and Public Health, *Department of Oral Surgery, Osaka Medical College, 2-7 Daigakumachi, Takatsuki City, Osaka 569, Japan.

*Fluoride* 30 (1) 1997