30.8

Fluorine and Related Compounds

Linda Rosenstock

EXPOSURE SETTINGS

The element fluorine (F) is encountered mostly as fluoride, including calcium fluoride (CaF_2), cryolite (Na_2AlF_6), and aluminum fluoride (AlF_3). Calcium fluoride, also known as fluorspar or fluorite, is a primary source of fluorine and related compounds, particularly hydrofluoric acid. Cryolite, available both naturally and synthetically, is predominantly used in the aluminum production process and to a lesser extent in ceramics and glass production. Aluminum fluoride is used in ceramics, as a flux, and in chemical processing. The most ubiquitous exposure to fluoride is through drinking water, because of its documented prophylaxis for dental caries, although it is also universally present in air and foods.

HEALTH EFFECTS—ACUTE

Elemental fluorine, the gaseous fluoride, and a number of related compounds are highly irritating to skin and mucous membranes (see Chapters 12.1 and 20.2). Acute inhalation and ingestion of sufficient intensity have been associated with fatalities, but acute toxicity in the occupational setting is rare and the primary concerns are subacute and chronic effects.

HEALTH EFFECTS—CHRONIC

Chronic excessive exposure to fluoride—whether in occupational or endemic settings of unusually high fluoride content in water—can result in osteosclerosis, also known as osteo-

fluorosis, a well-defined condition characterized by altered bone architecture, with increased cortical porosity and hypervascularization and ligament and tendon calcification, particularly of the axial spine (see also Chapter 14.1). Elevated bone fluoride content in aluminum workers (in one series, mean content was about 5500 parts per million) has been found to correlate with radiographic changes; nonoccupationally exposed controls in that same report had a mean bone fluoride content of about 1000 parts per million. Numerous studies have shown remarkably high attack rates of osteosclerosis among aluminum potroom workers; as air fluoride content and employment duration increased, there was a greater likelihood of earlier onset of osteosclerosis, of increased severity and extent of involvement, and of an increased proportion of workers affected. Various grading schemata for osteofluorosis have been proposed. What remains uncertain is the extent to which the common musculoskeletal complaints of pain and limited movement in workers who have been exposed to fluoride can be attributed to excess fluoride exposure in the setting of normal radiographs and whether excess fluoride exposure independent of fluorosis predisposes an individual to arthritis.

Chronic respiratory sequelae—asthma and accelerated loss of ventilatory function—have been variably found in numerous studies of aluminum production workers. Whether the effect is due to sensitization, nonspecific bronchial hyperreactivity, or both is unknown. But the syndrome, known as potroom asthma, has been suggested to be due to fluoride and perhaps other respiratory irritant exposures. Exposed workers in this and other industries with fluoride exposure have been found to have chronic nasal changes, including atrophy, consistent with chronic irritation of mucous membranes.

In addition to thermal and chemical burns associated with fluorine and hydrogen fluoride exposure, dermatitis, which subsequently resolved when fluoride exposure levels were reduced, has been reported in aluminum production workers.

DIAGNOSIS, EVALUATION, AND TREATMENT

Acute dermal or ocular injury with fluorides, especially hydrofluoric acid, is an emergency requiring care in a facility with access to calcium- and magnesium-containing antidotes, both solutions and gels. Inhalation of these soluble compounds is treated like other irritant inhalation exposure (see Chapter 11.4).

The gold standard for fluoride body burden is an invasive test not readily available in most settings, namely, iliac crest bone biopsy. Urine fluoride levels are a reliable reflection of recent and, in some series, more chronic fluoride exposures. Preshift and postshift urinary testing can provide an indicator of daily exposures. Current NIOSH recommendations are that preshift levels should not exceed 4 mg/L and postshift levels should not exceed 7 mg/L. The current OSHA standard is 2.5 mg/m^3. There is good evidence that when this air standard is met and urinary fluoride measurements are less than 5 mg/L, the risk for osteosclerosis is very low. It is less clear whether exposure levels within this range are nonetheless associated with arthritis and other musculoskeletal complaints in the absence of radiographic change.

Respiratory symptoms and findings in fluoride-exposed workers should prompt full evaluation and consideration of the potential etiologic role of fluoride or other irritant or sensitizing exposures—the prevalence of respiratory disease also is likely to be correlated with levels of exposure. Although the specific etiologic agent and mechanism remain uncertain, aluminum production workers with airways dysfunction should have a systematic evaluation, including serial peak flow measurement during and away from work (see Chapter 11.1).

Other than the sporadic but documented occurrence of osteofluorosis from environmental water contamination, there are no other known sequelae of nonoccupational environmental fluoride exposure. There is no specific treatment for fluoride-related musculoskeletal and respiratory conditions other than reduction or elimination of further fluoride exposure.

PREVENTION

Prevention is based on efforts to reduce fluoride exposure in occupational settings and surveillance strategies to ensure the effectiveness of these measures. Interventions include periodic symptoms review with attention directed toward the respiratory and musculoskeletal systems, spirometry, and urinary fluoride and ambient fluoride monitoring.

Bibliography

Boillat MA, Garcia J, Velebit L. Radiological criteria of industrial fluorosis. Skeletal Radiol 1980; 5:161–165.

Felsenfeld AJ, Roberts MR. A report of fluorosis in the United States secondary to drinking well water. JAMA 1991; 365: 486–488.

Hodge HC, Smith FA. Occupational fluoride exposure. J Occup Med 1977; 19(1): 12–39.

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