

CLINICAL FEATURES OF EARLY STAGES OF OCCUPATIONAL FLUOROSIS UNDER THE COMBINED AND JOINT EFFECT OF PRODUCTION FACTORS

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SUMMARY: Over 1000 workers of hydrofluoric and cryolite enterprises and electrolysis shops of aluminium enterprises were examined. Subjects exposed to soluble hydrofluorides presented in the early stage of chronic intoxication with a variety of syndromes, that was characteristic of intoxication with poisons of general toxic action with involvement of hepatobiliary, digestive, circulatory and autonomic nervous systems. Combined exposure to fluorine compounds, heating microclimate and electromagnetic fields results in a graver involvement of the circulatory and autonomic nervous systems. Clinical and experimental data show, that osteoarthrosis deformans of the major joints (primarily elbow joint) must be regarded as one of the symptoms of fluorosis, when other intoxication signs are present.

Working conditions in the mining and processing of fluorite and in cryolite and aluminum production remain poor despite the introduction of protective measures. Every year, new cases of fluorosis are diagnosed, and in a number of regions of the country this disease is one of the foremost chronic occupational intoxications.

The clinical picture of occupational fluorosis, first described in 1932 as osteosclerosis, was subsequently supplemented by the observations of domestic and foreign authors [1-9]. It was proven that fluorine causes changes in the skeleton, accompanied by toxic lesions of many organs and systems. These lesions precede the appearance of characteristic changes in the bone tissue which is confirmed by x-rays.

Long-term monitoring of the health status of workers in various fluorine production facilities has enabled us to identify complex non-specific changes in the internal organs characteristic of the early (pre-radiological) stage of fluorosis [4]. It includes changes in the digestive system (toxic hepatitis, chronic gastritis, most often erosive) and the cardiovascular and autonomic nervous systems (dystonia, myocardiodystrophy, asthenic-vegetative syndrome). Of major importance in the diagnosis of the early stage of fluorosis is hepatotoxicity. Early changes under the influence of fluorine occur in redox processes in the body which correlate with the severity of the intoxication [7]; total hydroxyproline levels in urine change [5], a significant increase demonstrating pathological changes in the structure of the bone tissue. However, this set of symptoms was not generally accepted by Russian clinicians. This is probably due to the fact that fluorine compounds are rarely found in isolated form in production. Usually, workers are exposed to the joint effect of fluorine compounds (with different degrees of solubility and toxicity) and other adverse production factors.

Table 1 Concentrations of fluorine compounds in the air of the breathing zone of workers in fluorite plants, cryolite, and aluminum factories

Production	Total concentrations of fluorine compounds (mg/m ³)	
	one-time	mean-shift
Surface mining of fluorite	0.02-2.48	0.21 - 1.32
Deep mining of fluorite	0.01-8.40	0.69-1.70
Processing plants	0.90-397.5	1.40-205.68
Production of fluorine salts	0.31-2.39	0.54-1.48
Production of hydrofluoric acid	0.13-27.53	0.43-8.09
Production of aluminum	0.24-43.07	0.40-8.06

The purpose of this paper is to clarify the clinical manifestations of early stage fluorosis, depending on the characteristics of working conditions.

In recent years, more than 1,000 people working in various fluorine production facilities were examined at the institute clinic. We have considered the medical histories of 222 patients diagnosed with “occupational fluorosis.”

Depending on the characteristics of existing unfavorable production factors, analysis of materials was conducted for three professional groups. The 1st group included workers engaged in the production and processing of fluorite, the 2nd group—workers in cryolite factories, and the 3rd group—electrolysis operators and anode operators in aluminum production.

The primary unfavorable factor in these facilities is represented by fluorine compounds (Table 1), the highest concentrations being found in fluorite processing plants.

In fluorite mining, in addition to fluorine compounds, workers are also exposed to the effect of silicon dioxide, which is a component of mine dust as well as elevated levels of vibration, noise, and adverse microclimatic conditions specific to mining companies.

Workers in electrolysis plants (electrolysis operators, anode operators) at aluminum factories are affected by a complex set of harmful production factors, including, besides fluorine, dust containing alumina and carcinogenic polynuclear aromatic hydrocarbons (PAHs), unfavorable microclimatic conditions throughout the year, a constant magnetic field, and hard physical labor.

Yet during the processing of fluorite and production of cryolite, the levels of exposure to other harmful production factors are, as a rule, within acceptable limits.

It should also be noted that workers in the 1st group are mostly exposed to the effects of just slightly soluble fluorine compounds (calcium fluoride), but those in the 2nd and 3rd groups are exposed to both slightly and highly soluble fluorine compounds (hydrofluoric acid, sodium fluoride).

The specified groups of patients are comparable in terms of age (Table 2). Table 2 shows that workers in cryolite production facilities were the ones to develop the disease the fastest (15 years).

Table 2 Mean age and seniority in fluorine production facilities of examined patients

Group	Mean age	Mean seniority
1	46.7±1.2	17.8±1.5
2	45.0±1.4	15.0±1.3
3	44.2±0.5	20.3±0.5

In the 1st group of patients (Table 3), the most common type of visceral pathology was damage of the gastrointestinal tract (97.1% of cases), mostly in the form of chronic atrophic gastritis. In 41.7% of cases, atrophy of the gastric mucosa led to its erosion.

Myocardiodystrophy was diagnosed in 47.2% and dystonia in 36.1% of the patients examined, based on clinical data and in-depth instrumental examination of the cardiovascular system.

Chronic hepatitis was not diagnosed in the 1st group, although in some cases there were deviations in laboratory test results (in 50% of cases, the results of the functional test with galactose were abnormal and in 1/3 of the patients increased alanine aminotransferase activity and disorders of protein metabolism were found). In this group of patients, the diagnosis of fluorosis was often established based on changes in bone tissue.

A pathology of the gastro-duodenal system (erosive gastritis) was diagnosed more frequently in patients in the 2nd group, but signs of toxic hepatitis were found with almost the same frequency, which allowed us to establish in patients working in cryolite plants a “pre-radiological” stage (early manifestation) of fluorosis.

The most comprehensive clinical syndrome of the pathology of visceral organs was found in workers in the 3rd professional group.

Thus, when workers were exposed to slightly soluble calcium fluoride, the early stages of chronic intoxication are characterized by the presence of chronic atrophic gastritis, dystrophic changes in the myocardium, and degenerative osteoarthritis of the elbow and knee joints. This is explained by the fact that slightly soluble fluorine compounds mainly accumulate in bone tissue and lead to characteristic lesions of the skeleton. At the same time, internal organs are subject to a significantly lower toxic load. The only exceptions are organs which are “gateways” for the admission of toxins into the body, in this

case the gastro-duodenal system where the calcium fluoride powder enters with the mucus from the bronchopulmonary system. In these workers, fluorosis is usually diagnosed in stage I, and often in stage II.

Table 3 Occurrence of visceral pathology in established diagnosis of occupational fluorosis (by %)

Nosological entity	Group		
	1 st	2 nd	3 rd
Chronic gastritis	97.1	77.7	78.0
Myocardiodystrophy	47.2	18.5	24.5
Vegetovascular dystonia	36.1	14.8	49.1
Hepatotoxicity	Abnormal values in some tests		73.6

Highly soluble fluorine compounds dissolved in the biological fluids of the bronchopulmonary system can easily penetrate into the blood. As a result, not only the bone tissue, where the highest material accumulation of fluorine occurs, but also the tissue of all organs and systems of the body experience an increased toxic load because of the poison circulating in the blood. The clinical picture of chronic fluorine intoxication due to exposure to highly soluble fluorides is characterized by multiple syndromes typical of poisons with systemic toxicity.

Timely diagnosis usually detects fluorosis in its early stage.

The combined influence of fluorine compounds, heated microclimate, and electromagnetic fields on the body intensifies clinical autonomic nervous and cardiovascular system symptoms. The extent of these changes is sometimes so severe that, even during the early stages of fluorosis, patients require rational job placement. This is due to the fact that permanent magnetic fields increase the toxic effects of fluorine and the heated microclimate affects changes in hemodynamics.

The combined influence of fluorine compounds and vibration amplifies changes in the musculoskeletal system.

The role of fluorine in the development of degenerative osteoarthritis (DOA) of the large joints remains a controversial issue. Until recently, this pathology was not included in fluorosis syndrome. Meanwhile, regular medical examinations of workers in fluorine production facilities and their examination at the clinic have revealed a high frequency of DOA (Table 4) [4]. The prevalence of DOA proves to be high after only 5 years of seniority in the facilities studied, which was not observed even among iron rollers [4]. The prevalence of DOA increases substantially with seniority.

Among workers in factories where the fluorine load per shift was highest, the association of DOA with signs of osteosclerosis was significantly higher than in shaft sinkers, where the labor is much harder and where adverse effects of general and local vibration occur. Most commonly, DOA affects the elbows, which are less subject than the knees to the effects of physical exertion but have greater functional mobility and, therefore, an abundant blood supply during work.

Table 4 Incidence of DOA in workers in various facilities (as shown by regular medical examinations) (by %)

DOA	Production facility				
	Fluorite plants			Cryolite production	Aluminum production
	quarry	mine	processing factory		
Total	56.0	49.4	58.6	44.4	40.0
Elbow Joints	48.0	42.9	52.3	42.7	40.0

The materials obtained suggest that DOA is one of the earliest signs of lesions of the musculoskeletal system in workers in fluorine production facilities.

Clinical observations were confirmed by experiments on animals exposed to aerosols of CaF₂ in concentrations exceeding 100 times the MAC value (which actually occurs in the production environment). It was established that slightly soluble fluorides cause marked dystrophic changes in the joints, corresponding to manifestations of degenerative osteoarthritis. The process involves both the cartilage and periarticular tissues with sclerosis and mineralization of the synovium and joint capsule.

Thus, if AlF_3 causes necrobiotic changes with subsequent calcination of these areas, CaF_2 leads to mineral dystrophy.

Conclusions. 1. The clinical syndrome of the early (pre-radiological) stage of fluorosis in various production facilities has its clinical features conditioned by the different solubility of fluorine compounds as well as the nature of existing unfavorable production factors that increase the extent and frequency of lesions of the visceral organs. 2. The most pronounced changes in the internal organs were observed in workers employed in electrolysis plants of aluminum factories, having contact mainly with highly soluble fluorides. 3. Degenerative osteoarthritis of the large joints, especially the elbow, in the presence of other signs of intoxication with fluorine compounds should be included in the set of clinical symptoms of fluorosis.

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