CLINICO-HYGIENE ASSESSMENT OF THE COMBINED EFFECT ON THE BODY OF VIBRATION AND FLUORINE

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The study of the combined action of vibration and intense noise, muscular loads and cooling has made it possible to assess the probability of the development of vibration disease under these conditions and to provide a basis for the coefficients of increase in the risk of sickness [2]. Data have been accumulated on the combined action of vibration with compounds of mercury, zinc and arsenic, providing evidence of the effect of these substances on the clinical manifestations, the development terms and the occurrence of vibration disease [3].

The considerable numbers of workers involved in the recovery of fluorite ore by open cast and underground methods in different regions of Russia (Primorskoi Krai, Zabaikal'e, Buryatiya), Central Asia and also in the numerous factories for the production of aluminium are subjected to the combined action of vibration and compounds of fluorine. One of the most widespread compounds of fluorine – fluorite (calcium fluoride) – is an object of industrial production and is widely used in different branches of industry. The levels of vibration and noise and the concentrations of calcium fluoride often exceed the limiting permissible values and cause clinico-functional disturbances of the state of the health and even the development of occupational pathology – vibration disease and fluoride intoxication.

In contrast to the well studied isolated effect of vibration and fluorine, no clinico-hygienic assessment of their combined action was made before our studies.

Material and Methods. For the comparative clinico-functional studies we formed groups of miners exposed to the separate and combined effect of vibration and calcium fluoride under the conditions of fluorite and iron ore mines, which are similar in terms of climato-geographic conditions, principal working condition factors and work processes but differ in terms of the presence of fluorine in the air of the work zone of the fluorite mines in connection with the 20-50% content of calcium fluoride in the ore. During the drilling of blast holes, the support of mine workings and the loading of the rock, the concentration of fluorine in the air of the work zone varies from the LPC to concentrations exceeding the shift average (0.5 mg/m^3) and the maximum one-time dose (2.5 mg/m^3) concentrations by a factor of 1.4-2.4.

The same type of hand held and reciprocating drills (PR-30, PP-63, PT-29, PT-36) are used in the mines under comparison. Allowing for the period of drilling in a shift (2.5 h on average), the equivalent local vibration levels to which the drill operators are exposed exceed the permissible (according to SN 3041-84) vibration speed levels in the octave frequency bands 16-125 Hz by 4-10 dB and the equivalent corrected vibration speed level by 7-12 dB. The noise levels are 4-36 dB higher than those permitted by SN 3223-85 in the 31.5-8000 Hz octave bands and the permissible sound level by 26-30 dB A.

Amongst the 558 miners from fluorite and iron ore mines who underwent the clinico-functional examination, the principal form of occupational pathology was vibration disease. In miners from the fluorite mines we also found accumulation in the body and signs of the toxic effect of fluorine. The indices of fluorine excretion with urine were 2.4-3.1 mg/l as against 0.78-0.8 mg/l for the population in the regions surrounding the mine and 0.47-0.54 mg/l in miners from the iron ore mines. In a number of miners from the fluorite mines we diagnosed suspected occupational fluorosis or fluorosis of degree I.

An analysis of the clinico-functional manifestations of vibration disease in the miners showed that patients in the fluorite mines had significantly more frequent complaints of paraesthesia of the hands, pains in the elbow and knee joints, and the bones of the shins and forearms (28.1-78.1 as against 3.6-17.8%, $p < 0.05$). Under the conditions of the fluorite mines, there was a higher frequency of occurrence than in the iron ore mines of polyneuritic sensitive disorders in the upper limbs and in 53.1% of the patients from the fluorite mines we observed hyperesthesia in the hands and forearms (up to the level of the elbow joints) compared with 14.3% of patients in the iron ore mines ($p < 0.05$). In patients from fluorite mines there is a much higher occurrence of vegetative-sensory polyneuropathy not only of the upper but also of the lower limbs: numbness, hypothermia, cyanosis of the feet, and a reduction in the pain and vibration sensitivities in the feet.

In the X-ray examination of vibration disease patients in fluorite mines, we observed a greater frequency of narrowing of the osteo-cerebral canals, thickening of the endosteal layer of the bones of the forearms and shins (28.0 as against 9.7%), deforming osteoarthroses (DOA) of the elbow joints (48.7 as against 12.9%, $p < 0.05$), and osteochondrosis and spondylitis of the cervical section (83.3 as against 41.1%, $p < 0.01$) and of the lumbar section of the spine (92.6 as against 71.9%, $p < 0.05$). It should be noted that DOA of the elbow joints was the cause of a stable loss of occupational working ability in 57.8% of vibration disease patients in fluorite mines and 15.4% in iron ore mines ($p < 0.02$).

A functional study of the blood circulation system in vibration disease patients in fluorite mines revealed changes in the cerebral hemodynamics with more pronounced angiotenic reactions – from the rheoencephalographic data; and changes in the hemodynamics of the liver and lungs in rheohepato- and rheopulmonography. From the ECG data we found a higher incidence of dystrophic changes in the myocardium, arterial hypertension and disturbance of the regulation of the cardiovascular system detected by tetrapolar rheography. The

clinical symptoms and data from biochemical studies (disturbance of the protein synthesis and carbohydrate function of the liver, reduction in the calcium content in the blood serum, deviations in the hydroxyproline and creatinine content) indicate a more pronounced damage of the liver and the endoscopy data suggest damage of the stomach of the chronic atrophic gastritis type in patients with vibration disease from the fluorite mines.

The clinical and functional data given above indicate that vibration disease in fluorite miners develops against a background of an enhanced accumulation of fluorine in the body and the manifestations of its toxic effect. In 16.1% of the patients, we diagnosed, in addition to vibration disease, occupational fluorosis.

The terms of development of vibration disease under the conditions in the fluorite mines were significantly shorter than those in the iron ore mines: the first signs of sickness appeared after 6.8 and 8.0 years respectively ($p < 0.05$), and the second degree develops after 14.4 and 17.7 years ($p < 0.05$). The occurrence of vibration disease is a factor of 1.8 times higher under the conditions of the fluorite mines.

A chronic experiment to study the combined effect of vibration and fluorine was planned in terms of a two-factor dispersion complex on groups of white non-parous mice. One group of animals was subjected daily to a 2-hour exposure five times a week of vibration with predominant energy in the 31.5 and 63 Hz octaves, an equivalent corrected vibration speed level of 117 dB. The second group was exposed to the inhalation effect of a disintegration aerosol of fluorite concentrate (47.9 mg/m^3) and the third group to the combined effect of these factors. The fourth group served as a control. The calcium fluoride concentrations were close to the threshold of chronic action and were developed by the construction of experimental models of intoxication by this compound.

The combined action of vibration and fluorine causes more pronounced shifts of some integral indices of protein and mineral metabolism in comparison to the isolated effect of each of the factors. In an X-ray study, changes in the long tubular bones and DOA of the large limb joints were found at earlier terms and with a greater frequency of occurrence. With the combined action of these factors we observed an enhanced accumulation of fluorine in the bones and teeth (from the second month of the experiment) and a reduction in the excretion of fluorine with the urine in comparison to the action on the body of fluorine alone. The main type of combined action of vibration with fluorine is the summation of their effects, as confirmed by dispersion analysis [3].

These clinico-hygiene and experimental studies have enabled us to find a basis for a set of recommendations on the prophylactics of occupational pathology in fluorite mines. Together with the limitation of vibration, measures must be used to prevent the toxic effect of fluorine. Thus, the control of the dust content of the air in the workings of fluorite mines should be based not only on the necessity of ensuring the LPC for dust, in terms of the SiO_2 content, but also of fluorine (which has a content of more than 25% in the dust).

If preliminary and periodic medical examinations are carried out, it is necessary to bear in mind contraindications to acceptance for work not only with exposure to vibration and noise but also the action of fluorine; it is recommended that with miners of more than 7 years service X-ray examination should be carried out of the long tubular bones once every three years and the level of fluorine excretion with the urine should be determined.

In the qualification of the degree of severity of vibration disease from the action of local vibration in fluorite miners it is necessary to take into account the probability of the early development of vegetative-vascular and polyneuritic disorders in the lower limbs and also DOA of the elbow and knee joints and the possibility of a combination of vibration disease with manifestations of the toxic effect of fluorine.

The determination of the risk probability of vibration disease should be made by using the coefficients of increase in the risk of sickness not only as a function of noise, temperature of the environment and category of severity of the work [1] but also the toxic effect of calcium fluoride, the effect of which can be estimated, in our opinion, by increasing the risk of sickness by a factor of 2.

Conclusions. 1) In addition to the harmful factors of the working environment characteristic of underground mining, miners in fluorite mines are exposed to calcium fluoride in the air of the work zone. 2) The principal form of occupational pathology in fluorite mine miners is vibration disease. Together with the special features of the clinical manifestations caused by the combined effect of vibration and fluorine, it is characterized by shorter terms of development and a reduction in the occupational working ability and may be combined with occupational fluorosis. 3) The combined effect of vibration and calcium fluoride in an animal experiment causes a more pronounced effect than the individual factors, deviations in the state of a number of systems and also changes in the kinetics of fluorine in the body.

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