Neurophysiological Mechanisms of Neurological Disorders in People Irradiated in the Chernobyl' Catastrophe

E. A. Vashchenko, A. I. Nyagu, and B. A. Brous

INTRODUCTION

A dramatic increase in the frequency of mental and neurological disorders in people affected by the catastrophe at the Chernobyl' nuclear power station (ChNPS) determines the enormous scientific and practical importance of the problem of the mechanisms of ionizing radiation-induced influences on the human nervous system. This problem has been intensively discussed within the scientific community; yet, even more than 12 years after this unprecedented catastrophe there is no agreement between the views on relations between pathological modifications in the nervous system and effects of ionizing radiation [1-6].

A number of specialists believe that psychoemotional stress is the crucial factor determining a progressive negative change in the overall health of people after such an extreme situation. Radiation-related factors are either neglected altogether (it is supposed that the radiation levels observed within the Chernobyl' zone are incapable of evoking noticeable injuries to the nervous system) or these factors are believed to be secondary [7-9].

To elucidate the etiology of the psychoneurological disorders and neurophysiological mechanisms responsible for them, we need to obtain objective quantitative characteristics of modifications in the nervous system of irradiated persons.

In this communication, we summarize the results of a complex clinical and electroneuromyographic examination of the functional state of the autonomic and somatic nerve mechanisms in the people irradiated in the Chernobyl' catastrophe.

METHODS

The functional state of the nervous system was studied with the use of a standard technique of detailed neurological medical examination in 760 persons of different categories subjected to irradiation in the ChNPS catastrophe. This was supplemented with electroneuromyographic testing of 233 persons involved in the cleanup and repair work of 1986 (hereafter, cleanup workers), 91 persons working within the 30-km excluded ChNPS zone but later on after the catastrophe, and 26 persons who permanently live within the territories with high radionuclide contamination.
One hundred cleanup workers (95 men and 5 women), who were subjected to relatively short-lasting but high-intensity irradiation (the accumulated dose was the highest, 0.7 to 6.5 Gy; within the context of our study this irradiation should be considered acute) were classified in group I. These people suffered from acute irradiation syndrome (AIS), and they were evacuated from the ChNPS zone after a relatively short stay.

Group II included 49 cleanup workers (men), who worked at nuclear power stations before 1986, took part in the 1986 repair work, and then continued to work within the 30-km excluded zone. Thus, they were continuously subjected to chronic irradiation of a relatively low intensity, but over longer periods.

Group III consisted of 84 men involved for 1-3 months in the cleanup work of 1986. They did not work before and after this period on the nuclear power stations.

Measured doses of external irradiation in the group II and III persons were lower than those in group I; they varied between 5 and 100 cGy and did not evoke AIS. Yet, the real doses in many cases could be considerably higher because of deficiencies in the system of dosimetric control.

Twenty six men constituted group IV; these were the forestry workers permanently living within the radionuclide-contaminated Ukrainian territories and thus subjected to chronic, mostly internal irradiation.

Group V included 69 persons who worked within the excluded territories in a watch mode. They were not involved in the 1986 repair work. Among them, two subgroups were distinguished. Twenty seven men constituted subgroup Va; they did not stay earlier within the territory of strict radiation control. Subgroup Vb was formed from 42 women who worked at the ChNPS before the catastrophe or lived near the station. In late April – early May, 1986, they were subjected to the catastrophe-related factors, then evacuated, but later on (after 1-3 years) returned and began to work within the excluded zone.

We also distinguished group VI, 22 men who worked within the above zone and also worked earlier on different enterprises of the nuclear industry.

Twenty healthy persons who did not work in the field of nuclear energetics and never visited the catastrophe zone were considered the control group.

Neurophysiological tests were performed with the use of a standard electroneuromyographic system for clinical examinations; the possibilities of the equipment allowed us to average recorded potentials and to measure their parameters with sufficient accuracy and digital indication.

To characterize the functional state of the somatic and autonomic reflex mechanisms, we measured the following indices: (i) parameters of sensory evoked potentials (EP) developed in the n. medianus after electrical stimulation of afferent fibers in the fingers (i.e., predominantly the cutaneous afferents) and recorded from the surface projections of this nerve; (ii) parameters of EMG responses of the m. abductor pollicis evoked by transcutaneous stimulation of the n. medianus (i.e., of the M responses of this muscle); (iii) modifications of the amplitude of the M response negative wave in the course of rhythmic stimulation of the n. medianus (3 sec⁻¹; this index characterized the state of neuromuscular transmission and muscle fatigue); (iv) parameters of H reflex and M response of the n. soleus evoked by stimulation of the n. tibialis posterior; we used a standard H reflexometry technique, which allowed us to characterize transmission in a monosynaptic segmental reflex arc; and, last, (v) parameters of evoked sympathetic skin response (SSR), which characterize the state of the sympathetic reflex sphere. SSR were recorded from the palm or feet surfaces, and evoked by intensive (near-nociceptive) transcutaneous stimulation of the contralateral n. medianus or n. tibialis, respectively.

The data were analyzed with the use of standard variational statistics techniques. Other technical details have been described in more detail in our earlier communications [10, 11].

RESULTS

In practically all examined people, psychoneurological disorders were observed. They should be believed based on pathology of the diencephalo-limbico-reticular structures with the dominating injury to the sympathetic section of the nervous system and were clinically manifested in a psychoautonomic syndrome combined with progressing autonomic insufficiency, i.e., integral components of an autonomic dysfunction. A complex of variable vegetotrophicvascular and sensory-algetic disorders together with the disorders in muscle tone was characterized by their generalized and symmetrical pattern.

Clinical data on manifestations of autonomic dysfunction in the examined people were clearly comparable with significant and typical modifications of sympathetic skin responses (SSR) in these persons. This potential is now widely used as an index of the state of the sympathetic (and autonomic, in general) reflex sphere in humans. In fact, it represents an initial component of the skin galvanic reaction based on a complex polysynaptic autonomic response usually evoked by stimulation of somatosensory afferents. This response is considered produced by the activity of sympathetic efferent fibers, first of all sudomotors and vasomotors innervating cutaneous vessels. Central structures responsible for SSR generation have not been finally indentified. It is believed that spike trains