Opinion

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Morphological Verification of Neuropsychiatric Disorders at Low Radiation Exposures

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Despite the significant contribution of stress factors to the picture of the Chernobyl post-accident period neurological disorders, a number of researchers identify obtained data with the results of the destructive ionizing radiation effects. Health disorders that increase over time are in most cases caused by neurological disorders of organic origin. However, researchers do not provide direct evidence of organic changes in the brain under low radiation exposures, although the need for this was identified in early scientific programs aimed at eliminating the consequences of the Chernobyl accident. The purpose of this work was to study in a radiobiological experiment the neuromorphological correlates of cerebral disorders during radiation exposure in doses equivalent to those obtained by the liquidators of the Chernobyl accident consequences. The experiments, in compliance with the rules of bioethics, were performed on 180 white mongrel male rats aged 4 months, who were exposed to emergency radiation in doses from 0.1 to 100 cGy. Brain regions (frontal and parietal cortex, thalamus, caudate nucleus, cerebellar worm) were studied throughout the life of animals in the postoperative period using standard neuromorphological, histochemical and statistical techniques, as well as mathematical modeling methods to determine the prognosis of the identified disorders development. The control was animals that were exposed to false exposure and examined at the same time as the irradiated ones.

Studies have shown that in control animals, the ratio of neurons of normal, hypo- and hyperchromic types changed with age, their size decreased, the size of the cytoplasm, nucleus and nucleolus, and the number of nerve cells with destructive changes increased. There was a tendency to decrease the number of neurons per area, and in the motor cortex this led to a statistically significant depletion of large pyramidal neurons population. There was also a decrease in the content of protein, nucleic acids, biosynthetic and energy processes in neurons. These data should be taken into account when evaluating neuromorphological effects in the long-term period after radiation exposure. Morphological studies of irradiated animals confirmed our earlier observations, indicating the absence of functionally significant pathomorphological changes in the brain under these modes of radiation exposure. Neurons with alterations, as a rule, were scattered in the field of vision, did not form pathological foci and did not impoverish the population of nerve cells in comparison with the age control.

Throughout life after radiation exposure, changes of varying severity prevailed in the studied brain regions, reflecting variants of the functional nerve cells activity. In some cases, the changes in neurons exceeded the levels of physiological variability, and on the other hand, they had not yet reached the level of typical pathological changes. The dynamics of the nerve cells number with both increased (hypochromic) and reduced (hyperchromic) functional activity was characterized by the greatest lability, especially in the motor zone of the cerebral cortex and the cerebellar cortex. Although morphological changes in such neurons were functional and reversible, a statistically significant increase or decrease in their number can affect the functional state of the entire brain. Radiation-induced changes in nerve cells during the irradiation period, as well as the neuropsychiatric disorders observed in irradiated individuals, were characterized by a wave-like undulating course with stochastic extremes in separate dose and time intervals. In this regard, significant changes in the nerve cells number in a state of both excitation and inhibition of functional activity, despite the absence of significant pathomorphological manifestations in the brain, may be the neuromorphological equivalent for transient neuropsychiatric disorders.

Along with this, mathematical modeling showed that radiation exposure in doses equivalent to those of the Chernobyl radiation accident liquidators caused a fairly pronounced response in most indicators of the nerve cells condition, but the resulting damage was quickly repaired. It is quite possible that some of the changes in neurons persisted and over time, accumulating, manifested themselves in the deviation period by separate stochastic extremes. Thus, fluctuations in neuromorphological parameters in the postoperative period, despite their stochastic nature, indicated a violation of the constancy of the structural organization and intensity of nerve cells functioning. These manifestations, along with significant wave-like changes in the nerve cells functional activity, can be the morphological basis for the subsequent formation of borderline brain functioning disorders. Unfortunately, experiments to study morphological changes in brain neurons throughout life after radiation exposure in doses that do not cause deterministic consequences have not been conducted before, and it is not yet possible to compare our data with other studies.

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