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TITLE: The Effect of Ionizing Radiation on Recurrent Inhibition
of the Spinal Cord

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Spinal Cord

The effects of radiation on the central nervous system were first studied experimentally by a Russian investigator, I. R. Tarkhanov, in 1896. He suggested that spinal reflex activity and convulsions due to the drug strychnine may be altered by X-irradiation. In spite of this very early start, studies of the effects of radiation on the spinal cord are relatively few. Soviet workers have reported effects on somatic reflex activity at remarkably low doses (Stahl, 1959; Stahl, 1960; Livshits, 1960; Lebedinskiy and Hakhil'nitskaya, 1963). An increase in latency of the knee flexor reflex in rabbits was reported for exposures as low as 0.1 r of whole-body irradiation (Kudritskiy, 1966). A whole-body exposure of 10 r was found by Fedorova (1958) to increase the latency of the flexor reflex and to produce greater variability in response time during the first 8 to 10 days following irradiation. By and large the techniques of investigating the spinal cord and radiation were fairly crude until the 1960's when some rather sophisticated neurophysiologic techniques were brought to bear on the problem. Among these were a number of studies by Sato, et al. (1961, 1962, 1963, 1964), using microelectrodes to record from single units in the spinal cord. These studies pointed to the synapse as the site of radiation effect. Studies in this laboratory have shown that the facilitatory synapse appears to be the most sensitive, resulting in increase facilitation and presynaptic inhibition to the monosynaptic reflex.

Fetal CNS

It has been observed that fetal tissues pass through a stage of development during which they are particularly vulnerable to the effects of ionizing radiation (Hicks, 1958). Two kinds of cells appear to be radiosensitive in the developing nervous system: those entering the prophase of mitosis and primitive differentiating cells (Hicks, et al., 1961). The understanding of the effects of X-irradiation on the differentiation of neurons is made difficult by an absence

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of knowledge concerning that which constitutes a direct effect of, by inference, the contribution of this effect to the formation of any of the definitive abnormalities observed. Many of the sequelae may be secondary to the primary effect on the mitotic apparatus (Ledebinsky, Mastryukova, and Strzhovshky, 1961) of ependymal cells which in turn cause not only the death of many elements but also sterilization of those which survive, with the further result that the development of certain neural tissue is effectively halted. Berry, in 1963, emphasized an apparent differential effect of radiation on the thalamus and cortex, inasmuch as the thalamus in each irradiated group of animals remained relatively unharmed histologically, he contends, than the normal projections from this structure to the cortex may be maintained. The EEG of prenatally irradiated rats has been demonstrated to be smaller in amplitude than those of normal animals and exhibited an abnormal amount of fast, spikey activity which occurred in bursts (Berry, et al., 1963). Specific evoked responses were demonstrated to be longer in latency and have a lower amplitude in X-irradiated animals than in normal animals, and these changes become more pronounced the earlier in fetal life the X-irradiation is applied (Berry, 1964). Proposed possible explanations for these results is that an abnormal synaptic arrangement within the specific projection system from the thalamus to the cortex has been developed in the irradiated animal. This contention has been supported by studies by Berry and Eayrs (1966), demonstrating a quantitative change in the basal dendritic fields showing that both the number of dendrites originating from the soma and the branching index are lower in irradiated cortices than a corresponding sample taken from normal rats.

A number of investigations have emphasized the relative radiosensitivity of cortex in mature and immature animals. Little attention has been focused, however, on the functional changes in the cortex subsequent to irradiation. An outstanding exception is the work of Shofer, et al. (1964) on the immature cerebellar cortex. This study reported that the functional consequences of destruction of the external granular layer and changes in the development of Perkinje cell dendrites and superficial axodendritic synaptic pathways due to radiation are increased excitability and complexity of afferent evoked responses and the failure of locally evoked activities to develop normal components.

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