IMPAIRED NEUROBEHAVIORAL FUNCTION FOLLOWING RADIATION EXPOSURE

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INTRODUCTION

Risk assessment of the biological consequences of living in the space radiation environment represents one of the highest priority areas of NASA radiation research. Of critical importance is the need for a risk assessment of damage to the central nervous system (CNS) leading to functional cognitive/behavioral changes during long-term space missions, and the development of effective shielding or biological countermeasures to such risks. Research is described that addresses this need via the development and application of a comprehensive animal model to provide for: 1) an assessment of the effects of radiation exposure on cognitive, behavioral, sensory, and motor function; 2) the development of behavioral biomarkers for detecting potential damage or susceptibility to radiation-induced CNS damage; and 3) an assessment of the potential effectiveness of biological countermeasures for radiation-induced CNS dysfunction. In addition to increasing an astronaut’s risk for cancer and cataracts, there is recognition that radiation may have short-term as well as cumulative deleterious effects in multiple tissues, including the CNS. Ground-based studies indicate that radiation can induce neurobehavioral changes in rodents, including impaired performance on motor tasks and deficits in spatial learning and memory. The present study tested the hypothesis that radiation exposure impairs psychomotor function in Long-Evans rats.

METHODS

The long-term effects of radiation exposure on cognitive/behavioral function are assessed via adaptation of the human CANTAB neuropsychological test battery to evaluate the same cognitive/behavioral functions in animals. Different groups of subjects are trained on each of the CANTAB neuropsychological test procedures to obtain a complete profile of radiation-induced effects on cognitive/behavioral function in rodents. For the present study, sixteen rats were trained to perform a simple reaction-time (RT) task, requiring them to depress a lever for 1-3 sec. To receive a food pellet, the rats were required to release the lever within 1.5 sec of a release stimulus (correct trial). Releasing the lever prior to the release stimulus terminated the trial and was considered an error. Eight rats were exposed to head-only gamma radiation exposure (5 Gy at a dose rate of 1 Gy/min) and eight received sham-radiation exposure using the same anesthesia protocol.

RESULTS

A rodent training and testing facility has been developed to provide for automated, computerized assessments of cognitive, behavioral, sensory, and motor function in research subjects on a daily basis. The facility supports both the exportation of groups of well-trained subjects to NASA-related radiation exposure testing facilities (e.g., Brookhaven National Laboratory) as well as the importation of radiation-exposed rodents from such facilities for detailed, long-term neurobehavioral risk assessments at the testing facility.

Percent correct scores decreased significantly and false alarms increased significantly one to six months following radiation, clearly indicating impairment in RT performance. The increase in premature releases is consistent with reduced inhibitory control, and a shift towards increased anticipatory responses at the cost of decreased accuracy. The non-radiated group showed no changes in RT performance over the same time period. These results clearly show cognitive/behavioral impairment following head-only gamma radiation exposure in rats, and also validate the sensitivity of the indicated measures.

SUMMARY AND CONCLUSIONS

The results of these experiments confirm the feasibility of an animal model approach for assessing neurobehavioral risks associated with living in a space radiation environment, and demonstrate the sensitivity of cognitive/behavioral test measures to the effects of head-only radiation that produce highly specific effects on neurobehavioral function.