

BRAIN DAMAGE FOLLOWING EXPOSURE TO LOW DOSES OF IONIZING RADIATION AS A RESULT OF THE CHERNOBYL ACCIDENT

Konstantin Loganovsky

Dear Editors,

The long-term unfavorable impact of the Chernobyl disaster on *mental health* is internationally recognized (UN Chernobyl Forum 2006, Bromet and Havenaar 2007, Bromet et al. 2011). Effects on a developing brain and organic brain damage in the Chernobyl accident clean-up workers (liquidators), both with cognitive dysfunction are considered among priorities to be explored. There is also an increasing pool of evidences concerning radiation risks of cerebrovascular disorders following exposure to low doses of ionizing radiation (Shimizu et al. 1999; Ivanov et al. 2001, 2006; Buzunov et al. 2001, 2011; Preston et al. 2003; Azizova et al. 2011).

A prospective 3-point neuropsychiatric study of prenatally exposed persons: (1) WHO Pilot project “Brain Damage *in utero*”, IPHECA (1992–1995, Nyagu et al. 1996); (2) French-German Initiative for Chernobyl (1998–2004, Nyagu et al. 2004); and (3) Study of National Academy of Medical Sciences of Ukraine (since 2010, Loganovsky and Bazyka et al.) is conducted by researchers from the Research Center of Radiation Medicine (RCRM) in Ukraine. An excess of cognitive dysfunctions was found among Chernobyl accident survivors exposed to low doses of ionizing radiation *in utero*. The cerebral and molecular-biological basis of these disorders is still unknown and should be elucidated.

Dose-related neuropsychiatric, neurophysiological, neuropsychological, and neuroimaging abnormalities following exposure to >0.3 Gy and neurophysiological and neuroimaging radiation markers at doses >1 Gy were revealed by RCRM in Ukraine. Radiation associated cerebrovascular effects were reported at >0.15 Gy (Ivanov et al. 2006). These health defects may be the consequence of accelerated aging due to radiation exposure which could be associated with cell senescence and telomere shortening (Bazyka et al. 2011, 2012). There exists an urgent need in finding out the cerebral and molecular basis of the cognitive impairment in Caucasian population exposed to low-dose irradiation.

According to the classical law of cancer radiotherapy by Bergonie and Tribondeau (1906), the adult nervous tissue was recognized as an excellent example of a “closed static population”, and, because of its fixed postmitotic state, this population was considered to be “extremely radioresistant”. At the same time, the evidence is dramatically increasing in support of the radiosensitivity of the Central Nervous System, CNS (Wong and Van der Kogel 2004, Gourmelon et al. 2005, Loganovsky 2009, Marazziti et al. 2012, Picano et al. 2012). There is a huge amount of new evidence

for the radiation-induced molecular and cellular basis of CNS effects following exposure to low doses of ionizing radiation: disrupted neurogenesis in the adult hippocampus (Andres-Mach et al. 2008, Kim et al. 2008), changes in the gene expression profile (Yin et al. 2003, Lowe et al. 2009), a neuroinflammatory response, neurosignaling alterations, apoptotic cell death, cell death and injury mediated by secondary damage, etc. together with the well-known role of the “glial-vascular union” in the pathogenesis of radiation brain injury. Thus, radiation exposure has multiple effects on the brain, behavior and cognitive functions. These changes depend largely on the equivalent dose received. Cognitive impairment induced by ionizing radiation is a paramount neuropsychiatric effect (Britten et al. 2012). However, these studies are experimental, and extrapolation of these results on the human brain seems to be at issue.

In prenatally exposed Chernobyl accident survivors cognitive dysfunction was found by different researchers from Russia (Yermolina et al. 1994–1998) and Belarus (Igumnov et al. 1994–2012). Moreover, cognitive deficit among prenatally exposed people to Chernobyl fallouts was registered in Scandinavia (Almond et al. 2007, Huizinik et al. 2008, Heiervang et al. 2009–2011) supporting our (Loganovsky et al. 2008) hypothesis on the disrupted development of the left, dominant, brain hemisphere. At the same time, other investigators found no cognitive effects in persons exposed in utero (Bromet et al. 1998–2011, Litcher et al. 2000, Bar Joseph et al. 2004, Taormina et al. 2008, etc.). There are NO studies on molecular basis of cognitive dysfunction in prenatally exposed people at all.

There are several epidemiological studies concerning cerebrovascular effects following exposure to low doses of ionizing radiation (Ivanov et al., Azizova et al., etc.). However, they do NOT provide both (1) comprehensive neuropsychological assessment, and (2) molecular-biological investigations.

There are many consistent reports about characteristic neurophysiological (Zhavoronkova et al. 1995–2012; Vyatleva et al. 1997, etc), neuropsychological (Khomsakaja 1995, Zhavoronkova et al. 1996–2012, Polyukhov et al. 2000, Turuspekova 2002, Gamache et al. 2005), neuroimaging (Kharchenko et al. 1995, Kholodova et al. 1996; Voloshina 1997, etc), and neuroimmune (Lysyanyj 1998) abnormalities in liquidators, supporting the clinical data about organic brain damage (Chuprikov et al. 1992, Krasnov et al. 1993, Romodanov et al. 1993, Revenok 1998, 1999, Zozulya et al. 1998, Morozov and Kryzhanovskaja 1998, Rummyantseva et al. 2002, Soldatkin 2002 etc). In summary, these reports testify to the organic brain

damage and accelerating CNS aging in clean-up workers following exposure to more than 0.25–0.5 Gy. At the same time, there are NO comparative radiation molecular neuropsychiatric studies in people exposed to low doses of ionizing radiation.

It is of great importance for clinical neuroscience and radiation biology to arrange international studies on the molecular basis of neuropsychiatric effects of exposure to low doses of ionizing radiation.

Literature

Bromet EJ, Havenaar JM, Guey LT (2011). A 25 year retrospective review of the psychological consequences of the Chernobyl accident. *Clin Oncol (R Coll Radiol)* 23, 4, 297-305.

Loganovsky K (2009). Do low doses of ionizing radiation affect the human brain? *Data Science Journal* 8, BR13–BR35 (http://www.jstage.jst.go.jp/article/dsj/8/0/8_BR13/_article)

Marazziti D, Baroni S, Catena-Dell’Osso M, Schiavi E, Ceresoli D, Conversano C, Dell’Osso L, Picano E (2012). Cognitive, psychological and psychiatric effects of ionizing radiation exposure. *Curr Med Chem* 19, 12, 1864-1869.

Picano E, Vano E, Domenici L, Bottai M, Thierry-Chef I (2012). Cancer and non-cancer brain and eye effects of chronic low-dose ionizing radiation exposure. *BMC Cancer* 12, 1, 157.

Corresponding author

National Research Centre for Radiation Medicine, National Academy of Medical Sciences of Ukraine, 53 Melnikov Str., 04050, Kiev, Ukraine

E-mail: loganovsky@windowlive.com