THE EFFECT OF UNDERGROUND NATURAL CHRONIC EXPOSURE OF FEMALE WISTAR RATS IN URANIUM MINE TO HIGH LEVEL OF RADON-222 PROGENY

Stela Râmboiu (1), E. Bordas (1), Adriana Olinic (2)

(1) Institute of Public Health, 6, L. Pasteur Street, 3400 Cluj–Napoca, Romania
(2) University of Medicine and Pharmacy, Histology Department, 6, L. Pasteur Street, 3400 Cluj–Napoca, Romania

The effect on fertility of chronic exposure of female Wistar rats in “Avram Iancu” uranium mine to high Radon-222 and Radon-222 progeny concentrations in air was investigated. Time variations of fertility index as well as the histological aspect of ovaries were analysed. The experiments were performed on adult Wistar rats (females) exposed for 52 days to high Radon-222 (28,749 Bq.m⁻³) and Radon-222 progeny levels in the underground air. The cumulated exposure of exposed rats was of 20.26 WLM. Two female control groups (underground and laboratory) were used. For both control groups Radon-222 level in the air was of about 78 Bq.m⁻³. As regard the external gamma dose there were not significant differences between the exposed and control groups. Each group was divided into three subgroups. The exposed rats were cross-mated with controls, five days after the end of the exposure (subgroup one) and six and ten months later (subgroup two and three, respectively). The fertility index was compared with that obtained for control groups. Immediately after mating the females were sacrificed and the ovaries were weighted and then embedded in paraffin and stained with hematoxilin-eosin. Histological aspect was analysed. Immediately after the exposure there were no differences between fertility index for exposed and control groups. Six months later the fertility indices for cross-mated group with control groups was zero. Ten months after the end of the exposure the fertility index remained zero. For both unexposed groups the fertility index do not changed in time. The weight of ovaries/100 g body weight for exposed group decreased in time. For the control groups no variation were found. Histology showed normal morphology in the ovaries of exposed rats immediately after the end of the exposure. The aspect does not differ for exposed and control groups. The chronic exposure of female Wistar rats to high level of Radon-222 and Radon-222 progeny lead to a significant alteration of the histological aspect of ovaries ten months after the end of the exposure. In controls the histological aspect of ovaries did not changed in time. These results suggest that the exposure of animals to Radon-222 progeny is related not only to high incidence of lung cancer, but also to sterility induction. The observed effect had a long latency period and could not be related to external gamma dose, which was too small to produce the observed effect.

Key words: fertility, Radon-222 progeny exposure

INTRODUCTION

Among the natural alpha emitting radionuclides, Radon-222 and its progeny has the most significant contribution to the radiation doses both for population and occupational exposed workers. The inhalation of Radon-222 daughters is associated with an increased incidence of lung cancer [Lubin et al., 1994, Tomasek et al., 1994]. Accordingly to available data, excepting the bronchial epithelium, the inhalation of Radon-222 progeny does not produce any considerable increase of radiation doses within other tissues and organs; at these levels the harmful effect can be considered practically non-existent.

The damage produced by ionising radiation is higher in tissues with rapid cellular turnover. The most radiosensitives organs and tissues are reproductive, hematopoietic and gastrointestinal systems [Schally et al., 1987]. Although experimental data certify the particular radiosensitivity of the germinal epithelium, both in acute and chronic irradiation, we have no information regarding a possible correlation between Radon-222 and its progeny inhalation and fertility decreasing as result.
of female exposure. In a previous study [Ramboiu et al., 1996] we analysed the effect of high level Radon-222 progeny inhalation on male rats reproductive organ and fertility after the cross matting with control groups. The obtained results suggested a possible late effect of Radon-222 progeny inhalation manifested by permanent sterility.

The aim of the paper is to present the histological aspect of ovaries as a result of chronic exposure of female rats to high Radon-222 progeny level in air in uranium mine, ten months after the end of exposure. The time variation of fertility index for cross-mated exposed females with control males, in comparison with unexposed rats, are also analysed.

MATERIAL AND METHODS

The experiments were performed on 80 young adult Wistar rats. The animals were divided as follows:
- Group I (females), (n=20), exposed underground in “Avram Iancu” uranium mine for 52 days to high level of Radon-222 (28,749 Bq.m\(^{-3}\)) and Radon-222 progeny in air. The cumulated exposure was of 20.26 WLM.
- Group II (females) (n=20), underground control, in the mine and in the same conditions of humidity, temperature, etc., excepting Radon-222 (962 Bq.m\(^{-3}\)) and Radon-222 progeny that were at the background levels. The cumulative exposure was of 0.51 WLM.
- Group III (females) (n=20), laboratory control.
  The mean body weight of females was of 160\(\pm\)15.5 g.
- Group IV (males), (n=20), laboratory control, with a mean body weight of 170.0 \(\pm\) 16.3 g.

For both control groups Radon-222 level in the air was of 78 Bq.m\(^{-3}\).

Radon-222 gas and Radon-222 progeny were measured with Lucas cells [Ramboiu et al., 1997]. Rock and Nazaroff’s methods were used for Radon-222 progeny determinations in the underground and laboratory air, respectively [Rock, 1975, Nazaroff et al. 1988]. The measurements were repeated three times in a day, for five consecutive days. The determinations were done at the beginning of exposure, 20 days after and at the end of the exposure. The mean values for each group were calculated. The external gamma dose rate was measured using a Curiemeter VAJ-100. As regard external gamma dose there were not significant differences between the exposed and control groups. Mean gamma dose rates for the exposed and control groups were of 0.40 \(\mu\)Gy/h and 0.32 \(\mu\)Gy/h, respectively.

Each group was divided into three subgroups. The exposed rats were cross-mated with controls five days after the end of the exposure (subgroup one), six and ten months later (subgroups two and three). The fertility index was compared with that obtained for control groups. Immediately after mating the females were sacrificed, the ovaries weighted and embedded in paraffin and stained with hematoxilin-eosin; the histological aspect was analysed.

RESULTS

The fertility index for exposed females matted with control groups (underground and laboratory) five days after the end of the exposure do not differ from the same index obtained by the matting of
control groups (Diagram 1). Six and ten months later the fertility of exposed females mated with control males decreased to zero. The fertility index for both control groups did not change.

Immediately after the exposure the weight of ovaries for exposed group did not differ from that of control groups. Ten month later the weight of ovary/100 g body weight for the exposed group I decreased from 22.3 mg/100 g to 18.5 mg/100 g. There were no differences between mean ovaries weight of underground and laboratory groups ten months after the end of the exposure (21.1 mg/100g and 20.5 mg/100 g, respectively).

Five days after the end of the exposure to Radon-222 and Radon-222 progeny the histological aspect of exposed females did not differ from control groups (Figures 1, 2 and 3). In the control underground animals, ten months after the exposure, the follicles were present in all stages of development: primordial, primary, secondary and tertiary (Graaf). Corpus luteum had a normal structure and in the medullary region the vessels and chiefly the veins were dilated and blood invaded (Figure 4). Ten months after the exposure to Radon-222 and Radon-222 progeny the following alterations were observed: lack of the Graaf mature follicles (Figures 5 and 6). Corpus luteum has a disturbed cellular structure, with the confluence of cytoplasm between the cells (Figure 7 and 8); the medullary zone presented a substantial hyperemia.

The results could not be explained by gamma radiation doses which were similar for exposed and control underground groups, and too low to produce sterility. It is possible that the long lived Radon-222 progeny obtained by desintegration of Radon-222 progeny accumulated at the level of respiratory system are circulated by blood and are accumulated at the level of female reproductive organs. Some studies regarding the possible accumulation of Pb-210 at the level of reproductive organs could explain this late effect [Ramboiu et al., 1989].

CONCLUSION
1. The fertility index becomes zero six months after chronic exposure of rats to high level of Radon-222 progeny in air.
2. The effect is not reversible, because ten months after the end of the exposure fertility index remains zero.
3. The sterility is explained by histological aspect of ovaries ten months after the end of the exposure.
4. The obtained results could not be explained by external gamma exposure, which is too small to produce alteration at the level of reproductive organ.

These results suggest that the exposure of animals to Radon-222 progeny is related not only to a high incidence of lung cancer, but also to the sterility induction. The observed effect had a long latency period of 10 months.

REFERENCES


Diagram 1: Time variation of fertility index

<table>
<thead>
<tr>
<th>Time</th>
<th>Fertility index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediately after the exposure</td>
<td>I (F) + IV (M)</td>
</tr>
<tr>
<td>Six months after the exposure</td>
<td>II (F) + IV (M)</td>
</tr>
<tr>
<td>Ten months after the exposure</td>
<td>III (F) + IV (M)</td>
</tr>
</tbody>
</table>
Figure 1: Normal aspect of ovary (control group) (H. E. x 100)

Figure 2: Ovary, five days after the end of the exposure to Radon-222 progeny (H. E. x 100)
Figure 3: Ovary of rats exposed to Radon-222 progeny, five days after the end of the experiment (H. E. x 100)

Figure 4: Ovary of underground control rat, ten months after the end of the experiment (H. E. x 100)
Figure 5: Ovary of rat, ten month after the exposure to Radon-222 progeny (H. E. x 100)

Figure 6: Ovary of rat, ten months after the exposure to Radon-222 progeny (H. E. x 100)
Figure 7: Ovary of rat, ten months after the exposure to Radon-222 progeny (H. E. x 100)

Figure 8: Ovary of rat, ten months after the exposure to Radon-222 progeny (H. E. x 100)