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Impact of Radiation on Male Reproductive System

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Annatation: This article provides information regarding the influence of various pathogenic factors on the human body, including the reproductive system.

Keywords: reproductive system, pollution, radiation.

Changes occurring in the environment (pollution), various chemical and physical factors affect the normal functioning of the body [1]. In this regard, the reproductive system is a "mirror" (highly sensitive) of the body, where the nature of reactions to various factors is not specific [2]. The reproductive system of a man is considered a separate topic for eternal discussions, and at present, a man, as an equal participant in the reproductive process, in comparison with a woman, is characterized by a higher morbidity and mortality and, accordingly, a shorter life expectancy. Of all the organs of the male reproductive system, the testes and epididymis are the so-called universal experimental organs, where the influence of factors to varying degrees can be studied quickly and clearly for preliminary reports and also for long-term results. Moreover, according to modern concepts, the epididymis is an adnexal gonad, in which the final maturation and accumulation of mature sperm occurs [3].

In the era of scientific and technological development, radioactive contamination is considered to be the most dangerous of all pollution, the sources of which are not only natural factors, but also, to a greater extent, anthropogenic activity.

The action of ionizing radiation to a large extent disrupts the balance of metabolism, which maintains the integrity of structures and homeostasis in the cells of various tissues of the body [4,5,6,7,8,9,10,11,12]. The development of radiation-biochemical effects is more pronounced in the radiosensitive tissues of the body, which include the tissue of the spermatogenic epithelium. Over the past decades, a lot of experiments have been carried out to study the morphological changes in the epididymis when exposed to various types of radiation. For example, long-term gamma irradiation with a low dose rate (13 × 10-6 kGy / s) on the body of laboratory white rats at the age of 2.5 months does not affect the overall dynamics of the weight of animals. However, testicular weights markedly decrease at doses of 0.1, 0.3, 0.6, and 1.0 Gy, with the latter dose being stimulating for prostate growth. Total sperm count and motility in the testicles and epididymis along with daily sperm production decreased in irradiated gamma rats compared to controls. Fractional irradiation at a total dose of 2.0 Gy in combination with anabolic drugs (ex. phenobolin at a dose of 2.5 mg/kg) led to a significant decrease in the relative mass of the testicles and, in particular, epididymis, as well as a decrease (by 3-5 times) the number of mature germ cells in the epididymis [3].

The parameters of the reproductive system were studied after irradiation of day-old rats with a low dose (3 Gy) of gamma rays. Irradiation led to a gradual depletion of maturation, consistently and reversibly affecting all cell classes of spermatogenesis. The mass of the testicles also decreased, but at the end of the experiment, a complete or almost complete recovery was observed. The effect of ionizing radiation with iron ions (2 Gy) on the reproductive organs was studied. The parameters decreased (including sperm motility) day by day and were the lowest 2 weeks after irradiation [2]. A similar experiment was carried out with carbon ion beams at a dose of 0.5 Gy and 4 Gy (Note: ion radiation is used to treat infertility) investigated the state of the reproductive system of male rats after irradiation at a dose of 2.0 Gy and stress (immobilization - 6 hours/day for 7 days) and their combined effects. On the 30th day after the combined exposure (37 days after irradiation), there is a decrease in testicular weight by almost 50% compared to the control and lesions associated with the process of spermatogenesis. In the remote period - on the 60th day (67th after irradiation), the effect of irradiation and irradiation in combination with immobilization stress leads to a sharp drop in the number of spermatozoa (up to 18% relative to the control group) and a decrease in their viability.

Abnormal sperm shapes have been used to assess the in vivo effects of low-dose gamma radiation. Six categories of abnormal spermatozoa were observed eight days after gamma irradiation (0, 0.5, 1 and 2 Gy) with a dose of high (0.8 Gy min (-1)) and low power. The frequency of complete abnormal sperm gradually increased from 0.5 Gy after high dose irradiation. The dose reduction effects on the incidence of abnormal spermatozoa in low-dose irradiated mice to high-dose irradiated mice were 1 at 0.5 Gy, 0.7 at 1 Gy, and 0.5 at 2 Gy. Researchers emphasize that low-dose radiation is not harmful to spermatogenic cells [13]. The above is a continuation of experiments where the dose rate effect ratio of low dose irradiated mice to high dose irradiated mice was about 0.6. And these studies have shown that low-dose radiation (0.7 mGy/h) does not damage spermatogenesis and probably stimulates the repair of damaged spermatogonial stem cells in male mice (?!) [13]. The long-term effect of radiation was also tested in monkeys that received doses of 4-8.5 Gy in immature age. It is concluded that exposure to adulthood has a significant long-term effect on the testis. Potential testicular size is reduced (23 to 13 g), seminiferous epithelium repopulation is usually incomplete, and aberrant Sertoli cells and dilated tubules form. The last two phenomena may have further consequences at even longer intervals after irradiation.

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Although the radioprotective effects of granulocyte colony-stimulating factor (GCSF) have been studied, the histopathological parameters of the exposed group (5 Gy to the pelvis) showed (at 12 hours and 21 days post-irradiation) a decrease in testicular weight, a decrease in the diameter of the seminiferous tubule, the thickness of the epithelium of these tubules, and the number of spermatozoa [13]. A number of authors [14] studied the effect of long-term irradiation at accumulated doses of 0.5 to 6.0 Gy (dose rate 3.03 Gy/day) on the mass of reproductive organs (testicles, epididymis, seminal vesicles, prostate) of male rats, starting from early ontogenetic period. On the first day after irradiation with a dose of 1.0 Gy, a significant weight loss was detected in the testes and epididymis. There is also evidence that the effect of irradiation is reversible. For example, four experimental groups were irradiated with fractionated doses: 1.5 + 8, 1.5 + 12 and 1.5 + 16 Gy (with an interval of 24 hours) and a single dose of 14 Gy. The non-irradiated mice were considered the control group. The testicles were removed 4, 6 and 8 weeks after irradiation, weighed and processed for microscopic examination. The number of normal tubules, epithelial thickness, tubal diameter, and luminal diameter were significantly reduced at high dose irradiation compared to control testes. Recovery was observed after 8 weeks (this also applies to the number of spermatozoa and their motility). This recovery period is contradicted by the result of another experiment. After low-intensity gamma irradiation in early ontogenesis with a total dose of 1.0 Gy, a decrease in the testicles and weight of the epididymis, an imbalance in relation to various spermatogenic cells, changes in the content of nucleic acid and a violation of bioenergetic metabolism in the testes were revealed. The disturbance of the reproductive system in rats persists in the long term (180 days after exposure) [11]. It was found that irradiation of mice at 630 nm with a He-Ne laser increased the level of intracellular calcium and increased their ability to fertilize [15].

Also, in experiments on rats, the morphology of the testes of rats was studied at different times (3, 10, 90 days) after a single total y-irradiation (0.5 and 1.0 Gy). Elements of destruction of the tubular apparatus of the testes (3-10 days after irradiation) and signs of subsequent restoration of their structure (90 days) were revealed. It was also found that after a single total γ-irradiation of male rats at a dose of 1.0 Gy, the processes of mitochondrial oxidation in the testes change, which is manifested by the activation of tissue respiration of spermatocytes, but is accompanied by uncoupling of oxidation and phosphorylation. It was concluded that signs of restoration of the structure and function of the testes are revealed after a single y-irradiation only after 3 months. At the same time, signs of edema of the testicular stroma disappear, and a partial restoration of the spermatogenic epithelium damaged by radiation occurs. Conclusion. Day after day, the role of external factors influencing the performance of the body and its systems, including reproductive ones, is increasing. And the normal functioning of the testis and epididymis has an indirect effect on the development of offspring. Therefore, active work is now underway not only to study the causes of negative changes, but also a course has been taken to find new ways to prevent and treat these pathologies. And here the use of biostimulants for immunomodulation, and with their help to enhance the regeneration process (for example, the testis and epididymis) is one of the potential solutions to these problems.

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