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Chronic Radiation Disease: Consequences and Outcomes

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INTRODUCTION

Great scientific and practical experience on the problem of the radiation deterministic effects in man was accumulated for last 50th years. The bone marrow form of the acute radiation disease (ARD) is described in greater details. The criteria of diagnostic, treatment on different stages of disease, the consequences of ARS are determined. In the conditions of chronic external radiation in large doses (significantly more than permissible dose) the injury of the high radiosensitive hemopoietic system is also developing.

In the beginning of 50th new nosological form of the radiation disease was found out in the atomic workers of the first atomic enterprise in Russia (PA "Mayak"). It received the name of chronic radiation disease (ChRD) and was described by A. Guskova and G. Baisogolov (1). In present article the results of long-term medical observation of workers, which has ChRD are presented.

MATERIAL AND METHODS

In 1948-1949 the reactor, radiochemical and plutonium production complex (PA "Mayak") began its operation. Th introduction of new complicated technologies, the short period for the production output, the absence of effective individual and collective protective means against radiation led to the excessive radiation exposure of the part of atomic workers. In 1949-1954 the annual radiation doses could achieve 1.0 - 4.0 Gy and the total doses were up to 4.0 – 10 Gy in the first 3-5 years of work. Beginning with the 60th the annual doses did not exceed the permissible dose (5 sZv per year). The part of the personnel also had the professional contact with plutonium0239 aerosols. The characteristics of the personnel's doses were presented in the article (2).

The medical control of the workers' health status was begun in the starting of the enterprise operations. The medical examination included the primary examination before employment and the further periodical (monthly, quarterly, annually) examinations by therapeutist, neurologist, blood count investigations and other researchers, if it was necessary. The system of periodical medical examination allowed find out the early changes of any health status of atomic workers. In the first decade of atomic plant activity more than 1800 occupational diseases induced by radiation exposure were diagnosed. Chronic radiation disease (ChRD) compiled more than 80% of these diseases. In specialized hospital the additional investigations and treatment (hemostimulated measures, vitamin therapy, etc.) were carried out. After the diagnostic of ChRD atomic workers continued work without any contact with ionizing radiation sources.

50 years passed since the PA "Mayak" started operations. The medical observation of most workers which had ChRD is continuing in the same medical center. The results of the long-term observation include the evaluation of status of hemopoiesis, nervous, cardiovascular, respiratory, gastrointestinal systems and other systems and organs. We estimated the health status of 632 atomic workers, which had the diagnosis of ChRD 49-50 years ago.

Many parameters of peripheral blood and bone marrow (sternal punction) for whole period of observation were analyzed. The local and common hemodynamic status (rheovasography, rheoencephalography, ophtalmoscopy), lung function, stomach function and morphological status of stomach mucous (aspiration gastrobiopsy) were studied. In late period of ChRD the immune investigations were carried out. The chromosome analysis of peripheral blood lymphocytes as the indicator of former radiation exposure was used. The complex of up to date methods of investigations was used for the correction of different somatic diseases. Also we studied the death causes of 563 atomic workers with ChRD diagnisis for 50 years of observation.

RESULTS

The clinical syndromes of chronic external gamma-irradiation in total doses 1.0 – 10.0 Gy for the period 1-7 years of work have been estimated retrospectively. The maximal annual doses varied from 0.7 to 4.5 Gy.

The leading syndrome of ChRD was the injury of the hemopoietic system. The count of leukocytes fell to 30-65% of the initial level (primary analysis). There was the decrease of neutrophils mainly. The count of trombocytes fell to 50-60% from the initial level. During the period of forming of ChRD the leucopenia and trombocytopenia were observed in more than 90% of workers (Table).

Table. The frequency of clinical syndromes of chronic radiation disease during the period of forming and late period of disease (%)

Clinical syndromes	Initial parameters	Period of disease	
		Forming	Late
Leucopenia Amount leucocytes <4.9 x 10^9/l <4.0 x 10^9/l	 11.6 0.8	 95.0 43.5	 26.0 5.1
Trombocytopenia (amount trombocytes less than 180 x 10^9/l)	24.0	91.8	11.0
Vegetative dystonia	9.0	78.0	4.0
Astenic syndrome	6.0	58.0	1.0
Syndrome of organic changes of nervous system of radiation encephalomyelosis type	0	24.0	1.0

The erythrocytes count of peripheral blood in most cases remained at initial level and did not decrease below the normal level for the long period. However moderate anemia in some cases when the annual radiation doses were more than 2.0 Gy was observed. The character and depth of cytopenia depended on dose-rate and total doses of external radiation. The progressive hypoplasia of hemopoiesis was the cause of death of 3 workers which had the annual and summary doses more than 4.0 Gy and 7.0 Gy respectively.

The changes of nervous system in most cases were observed simultaneously. These changes were characterized by following syndromes: vegetative dystonia (hypotonic type), astenic syndrome, organic changes of nervous system of radiation encephalomyelosis type. The character of changes of nervous system depended on dose-rate and total dose. Vegetative dystonia syndrome was forming at maximal annual dose 1.3 ± 0.1Gy (total dose 2.6 ± 0.4 Gy), astenic syndrome - maximal annual dose 1.4 ± 0.1 Gy (total dose 2.7 ± 0.1 Gy) and syndrome of radiation encephalomyelosis – 2.3 ± 0.1 and 4.5 ± 0.2 Gy, respectively. The dysfunction of thyroid (hyperfunction) and stomach dysfunction (hyposecretion) were observed in the same cases. During the period of forming of ChRD the radiation cataracts haven't been diagnosed (3).

After cessation contact with ionizing radiation sources the blood parameters in atomic workers gradually normalized. In the late period of ChRD the syndrome of moderate hypoplasia of hemopoiesis or moderate hypoplasia of granulocytopoiesis were observed in one out of ten cases of ChRD. The greatest amount hypoplasia (32%) was observed in workers, which had annual dose more than 2.0 Gy. In present time the hypoplasia of hemopoiesis is compensated and doesn't require any special treatment.

In the late period of ChRD the changes of nervous system are characterized by the evaluated frequency of early cerebral atherosclerosis (before the age of 45) in cases when maximum annual dose was more than 1.5 - 2.0 Gy and summary dose was more than 3.5 - 4.0 Gy. The frequency of cerebral atherosclerosis complications is not evaluated. We think than that cause of it is the intensive treatment and prophylactic measures (periodical prophylactic treatment in hospital, sanatorium, systematic vitamin therapy, etc).

Immune status in the late period of ChRD is characterized by reducing of the parameters of the cell immunity (T-helpers) in cases of high doses (more than 4.0 Gy) and by tendency of increasing of the infectious syndrome frequency (4).

The chromosome aberrations are the indicator of former ionizing radiation. In present time most patients with ChRD (88%) have the chromosome aberrations of both unstable and stable types (in control 12%). The frequency of chromosome aberrations is evaluated to be 4-8 times of spontaneous level.

During long-term observation the clinical symptoms of radiation cataracts were not observed. The involutional cataracts were forming at the corresponding age (3).

The stomach function was estimated. The character of secretion function and morphological status of the stomach mucous were studied at 400 patients with ChRD. 2000 hystological preparations from the different places of the stomach mucous were estimated. In the late period of ChRD the frequency of cases of the hyposecretion of stomach and character of morphological changes of stomach mucous corresponds to the character of these changes in the common population of industrial countries (5).

563 causes of death of workers, which had the clinical syndromes of ChRD (before 01.01.99) were analyzed. Malignant diseases (44.7%) and cardiovascular diseases (43%) occupy the leading place in the structure of death causes of patients. Lung cancer occupies one third in the structure of malignant diseases. It's important to note that lung cancer was diagnosed at those patients, which has content of plutonium-239 body burden. Also it's important to note that during first 3-7 years of the atomic plant operation the leukemia (acute myeloblust leukemia predominantly) was the leading disease in the structure of death causes in ChRD patients.

CONCLUSION

The chronic radiation disease (ChRD) is the syndromocomplex of the changes in most radiosensitive hemopoietic and nervous system evaluating after the chronic radiation exposure in doses significantly higher permissible dose (5sZv per year): maximal annual dose near 1.0 Gy, total external dose more than 2.0 Gy. In the late period of ChRD (after 40-50 years) there is the defect of the hemopoietic and immune system repair, unstability of somatic cells genome, acceleration of involutional process (the early cerebral atherosclerosis).

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