

RADIATION RISKS OF HELICOPTER PERSONNEL RESPONDING TO THE CHERNOBYL ACCIDENT: EARLY AND LONG-TERM HEALTH DISORDERS

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Abstract. The objectives of the study were to analyze the radiation doses received by helicopter crew members during the work above the emergency unit and the effectiveness of some radioprotective means; to determine the most radiosensitive systems of the body, their condition in the early and distant terms after the accident and the causes of disqualification of flight personnel.

Materials and research methods. The first stage of the work was performed directly in the zone of helicopter aviation flight over the Chernobyl NPP emergency power unit. We determined radiation doses received by flight personnel, their dependence on the type of helicopter and pilot's workplace. Also we evaluated the dependence of exposure dose on the radio-protective means used and the primary reaction of pilots to radiation exposure. The second stage of the work was performed on the basis of the Central Research Aviation Hospital and the State Research Test Institute of Military Medicine of the Russian Ministry of Defense. At this stage the results of laboratory, clinical and psychological examination of the pilots who performed the tasks of liquidation of the Chernobyl accident effects in 1986 - 1987 and received regulated radiation doses were assessed. The corresponding medical documents (expert decisions of medical and aviation committees, results of medical follow-up) were studied for the period from 1986 till 2000, i.e. till the time when almost all helicopter liquidators were disqualified for health reasons or discharged due to senior service.

Results of the study and their analysis. The radiation doses received by the helicopter crew members during the execution of the assigned tasks over the emergency unit and the efficiency of some radio-protective means were analyzed. The most radiosensitive body systems, their condition in the early and distant terms after the accident and the diseases leading to the disqualification of flight personnel were determined.

Key words: accident consequences elimination, Chernobyl accident, distant health disorders, early health disorders, helicopter pilots, human exposure to low doses of radiation, ionizing radiation radiation risks

Conflict of interest. The authors declare no conflict of interest

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РАДИАЦИОННЫЕ РИСКИ ВЕРТОЛЁТЧИКОВ ПРИ ЛИКВИДАЦИИ ПОСЛЕДСТВИЙ АВАРИИ НА ЧЕРНОБЫЛЬСКОЙ АЭС: РАННИЕ И ОТДАЛЕННЫЕ НАРУШЕНИЯ ЗДОРОВЬЯ

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Резюме. Цели исследования – проанализировать дозы облучения, полученные членами экипажей вертолетов во время работы над аварийным блоком, и эффективность некоторых радиозащитных средств; определить наиболее радиочувствительные системы организма, их состояние в ранние и отдаленные сроки после аварии и причины дисквалификации летного состава.

Материалы и методы исследования. Первый этап работы был выполнен непосредственно в зоне полета вертолетной авиации над аварийным энергоблоком Чернобыльской АЭС. При этом определяли дозы радиационного воздействия, полученные летным составом, их зависимость от типа вертолета и рабочего места летчика, а также оценивали зависимость дозы облучения от применяемых радиозащитных средств и первичную реакцию летчиков на радиационное воздействие. Второй этап работы выполняли на базе Центрального научно-исследовательского авиационного госпиталя (ЦНИАГ) и Государственного научно-исследовательского испытательного института военной медицины Минобороны России. На данном этапе оценивали результаты лабораторных, клинических и психологических обследований летчиков, выполнявших задачи по ликвидации последствий аварии на ЧАЭС в 1986–1987 гг. и получивших регламентированные дозы облучения; изучали соответствующие медицинские документы (экспертные решения врачебно-летной комиссии, результаты диспансерного наблюдения) за период с 1986 по 2000 гг., т.е. до того срока, когда практически все вертолетчики-ликвидаторы были дисквалифицированы по состоянию здоровья или демобилизованы по выслуге лет.

Результаты исследования и их анализ. Проанализированы дозы облучения, полученные членами экипажей вертолетов во время выполнения поставленных задач над аварийным блоком и эффективность некоторых радиозащитных средств. Установлены наиболее радиочувствительные системы организма, их состояние в ранние и отдаленные сроки после аварии и заболевания, приводящее к дисквалификации летного состава

Ключевые слова: авария на Чернобыльской АЭС, воздействие малых доз радиации на человека, ионизирующее излучение, лётчики вертолетной авиации, ликвидация последствий аварии, отдаленные нарушения здоровья, радиационные риски, ранние нарушения здоровья

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Thirty-five years have passed since that tragic day when the worst radiation accident in the history of mankind occurred. For the first time military aviation was widely used to eliminate its consequences. Its personnel were exposed to radiation. Already on the second day the crews of the arriving helicopters began to work above the destroyed reactor. Flights to the zone of Unit 4 of the Chernobyl Nuclear Power Plant (ChNPP) were performed for the purpose of dropping heat-removal and filtering materials and measuring radiation levels, including in "hover mode". Aviation was also involved in aerial surveying, reconnaissance of the area, decontamination of the territory and firefighting. More than 1 thousand members of military helicopter aviation crews took part in rescue operations in the early (up to 15 days after the accident) and intermediate (up to 2 months after the accident) periods. The external gamma and beta radiation doses to the liquidators were 0.05-0.5 Gy. The duration of stay in the zone with increased level of contamination by nuclear fission products was up to 10 days [1-4].

Along with the above mentioned, the accident at the Chernobyl NPP set a task for the military medicine to evaluate the nearest and distant consequences of low-dose irradiation. And also to develop on this basis a complex of organizational medical measures, contributing to maintaining the required level of health and working capacity of servicemen during their work in the radioactively contaminated area. This was mainly related to the peculiarity of the action of low radiation doses, namely to the occurrence of various diseases, including psychosomatic ones, among the liquidators [5-9]. Epidemiological studies have shown that during the first 5 years after exposure an annual increase of morbidity was observed in the liquidators. In 10 years 38% of 1986 liquidators had various chronic diseases. And the morbidity occurred in 50% of those surveyed who received a radiation dose of more than 25 cGy. It was shown that 70% of liquidators had the main disease for the first time after liquidation of the Chernobyl NPP accident consequences. And within 17 years the average number of diagnoses per one liquidator increased from 1.4 to 7.2 [10]. At the same time the number of neuropsychiatric diseases in the liquidators was more than 5 times higher than in the control group [11, 12]. No precise information on the pathogenesis of diseases and on the state of the most critical systems of the organism of liquidators exposed to undetermined doses has been obtained. Some researchers consider certain complaints of liquidators as a manifestation of the intention to receive additional benefits or as radiophobia [6]. In this regard, it is necessary to continue such studies, excluding the influence of concomitant factors of non-radiation nature and manifestations of radiophobia.

The objectives of the study are to analyze the radiation doses received by helicopter crew members during the work above the 4th unit of the reactor and the effectiveness of some radioprotective equipment; to determine the most radiosensitive body systems, their condition in the early and distant periods after the accident and the causes of disqualification of flight personnel.

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Materials and research methods. The first stage of the work was performed directly in the zone of helicopter aviation flight over the Chernobyl NPP emergency power unit. At the same time we determined radiation doses received by the flight personnel, their dependence on the type of helicopter and the pilot's workplace. We also evaluated the dependence of exposure doses on the radio-protection equipment used and the primary reaction of pilots to radiation exposure. The second stage of the work was performed on the basis of the Central Research Aviation Hospital and the State Research Test Institute of Military Medicine of the Russian Ministry of Defense. At this stage the results of laboratory, clinical and psychological examination of the pilots who performed the tasks of liquidation of the Chernobyl accident effects in 1986-1987 and received regulated radiation doses were assessed. The corresponding medical documentation (expert decisions of medical and flight committees, results of medical follow-up) was studied for the period from 1986 till 2000, i.e. till the time when almost all helicopter liquidators were disqualified for health reasons or discharged due to senior service. The methodology of the study of the health status of flight personnel from the moment of exposure to radiation until discharge from the Armed Forces (AF) was presented by us earlier [1] in sufficient detail.

The results of the study and their analysis. An assessment of the spatial and time parameters of the dose field directly over the reactor showed a significant radiation hazard when flying over the emergency unit. Therefore, for crews operating in emergency situations for 2-5 days, flying over the reactor was considered to be a factor determining the dose load [1]. In indirect assessment of dose loads on flight crews, the nature of the route, altitude, date, and time of day of flight over the emergency zone for each crew were taken into account. On this basis, assessment of dose loads on the crews under direct radiation of the emergency unit was given (Table 1).

The registry of the Institute of Aviation and Space Medicine included 101 army aviation pilots who were admitted to the Central Research Aviation Hospital at the end of April and the beginning of May, 1986. The radiation dose for this contingent was (28.3 ± 8.4) cGy – the variation coefficient was 30%. At the same time, 29 persons (28.7%) – according to the data of indirect dose assessment – 24 persons (23.8%) received doses over 25 cGy. Dose differences identified based on direct measurements and indirect assessment were as follows: within 5 cGy – 10.3%; 10 cGy – 43.3; within more than 10 cGy – 57.7%. The excess by more than 10 cGy of indirect dosimetry indicators in comparison with the indicators of individual dosimeters was noted in 78 pilots – 39.7% of cases. During the period of work from April 27 to June 1, 1986 the crews of Mi-26 helicopters received high doses of radiation (see Table 1).

Flight personnel who were admitted to the Central Research Aviation Hospital for examination were divided into two subgroups: helicopter pilots without comorbidities (no diagnosis) and helicopter pilots with comorbidities (Table 2).

In the 1st subgroup, the mean values of leukocyte count were $(6.0 \pm 0.1) 10^9/l$; red blood cell count, $(4.7 \pm 0.02) 10^{12}/l$; platelet count, $(277.3 \pm 6.1) 10^9/l$; in the 2nd subgroup these

values were (6.4 ± 0.2) ; (4.8 ± 0.02) and (284.3 ± 5.4) respectively. Relative lymphocytosis and reticulocyte reduction to the lower limit of normal were noted in 25% of cases in both subgroups.

During the period when the pilots passed the medical-flight commission at the Central Research Aviation Hospital, the structure of the diagnoses did not change. At the 1st regular medical-flight commission (June 1986 - May 1987) 23 pilots (28%) out of 81 received the following conclusion: "Healthy (without clinical and hematological manifestations)", in 58 of them diseases were diagnosed (Table 3).

After the 1st regular medical-flight commission (May 1987) 6 pilots were declared unfit for flying. Two of them had the diagnosis "urolithiasis", 4 — combined diagnoses, but the main, unifying diagnosis was "emotional and vegetative instability, prolonged neurotic state". At the second regular medical-flight commission the same conclusions about unsuitability for flying work were received by two more pilots. During the periods of passing the medical-flying commission at the Central Research Aviation Hospital (1986-1988) the quantitative blood indices changed little. However, relative lymphocytosis was noted in 50% of cases (the 1st medical-flight commission after work at the Chernobyl NPP) and 40% (the 2nd medical-flight commission). The number of reticulocytes remained at the lower limit of the norm. Thus, most blood analyses had no deviations from the norm, and the observed weakly pronounced shifts did not correlate with the radiation dose.

Against this background, a number of liquidators had increased emotional lability, irritability, rapid fatigue, headaches, dizziness, internal tension, sleep disorders, nightmares, withdrawal, decreased memory, impaired concentration, anxiety, etc. when performing the tasks. These symptoms increased with time (Table 4).

Although the detected borderline mental disorders were transient, in some liquidators they took on a compulsive character. Comparison of the dynamics of the number of liquidators with partial health deficiencies in the groups under analysis showed that the main increase in the morbidity among the exposed people occurred in the first 5 post-radiation years, while among non-exposed people it occurred in 1990-1993. Apparently, this can be explained by the fact that in 1986-1991 most of the liquidators underwent hospital examination, which contributed to earlier detection of diseases. The pilots of the control group underwent an extended examination only when they reached the age of 35, i.e. in 1990-1993. Nevertheless, the fact of prevalence of diseases in helicopter liquidators over those in the control group during all 15 years of observation is obvious (Figure).

During the three months of work to eliminate the consequences of the accident, 1,125 aircrew were exposed to radiation. The number of pilots exposed to over 25 cGy and hospitalized in medical organizations was 65 (5.8%); the number of those exposed to 21-25 cGy who were taken off the flight was 366 (32.5%); the number of those exposed to under 20 cGy who were discharged from the accident region was 673 (59.7%). It is noteworthy that in the 16-20 cGy dose 27.5% of the aviation personnel were suspended from flying. And at doses over 21 cGy 9.8% of the pilots were allowed to continue flying. This demonstrates that at that time the dosage accounting was imperfect, as well as the lack of unified tactics among doctors and commanders in deciding whether pilots should be allowed to continue flying persisted.

Fifteen years after participation in elimination of the consequences of the accident, the bulk of the flight personnel completed their professional activities. At the same time al-

most 90% of helicopter pilots had different diseases, among which diseases of cardiovascular (52%) and nervous (39%) system, musculoskeletal system (27%), gastrointestinal organs (21%), respiratory system (29%), sense organs (7%) and others prevailed. Experimental data and clinic of human radiation sickness demonstrate that exposure of the abdomen results in a pronounced primary reaction: vomiting, bloating, pronounced pain syndrome, sleep disturbance and other symptoms [1, 6, 7]. Therefore, on the path of the main flow of gamma radiation from the destroyed reactor when irradiating the helicopter from the lower hemisphere, a lead shield of 5 mm thickness (attenuation factor of 1.5) or more was placed on the seat cup. In combination with an additional shield an anti-radiation belt protecting the abdominal area made in the form of a cartridge with

Таблица 1 / Table No. 1
Дозы облучения, полученные экипажами вертолетов в период с 27 апреля по 1 июня 1986 г.
 Exposure doses received by helicopter crews from April 27 to June 1, 1986

Тип вертолета Helicopter type	Категория летного состава – число обследованных, чел. Category of flight personnel - number of surveyed persons, people	Средняя суммарная доза облучения, сГр Average total dose, cGy	Средняя продолжительность пребывания в зоне, дни Average length of stay in the zone, days
Ми-8 Mi-8	Командир – 73 Commander – 73	18,7±0,9	4,6±0,4
	Штурман – 74 Navigator – 74	18,8±0,9	4,4±0,4
	Борттехник – 74 Flight technician – 74	18,9±1,0	4,5±0,8
Ми-6 Mi-6	Командир – 47 Commander – 47	17,1±1,1	3,1±0,2
	Правый летчик – 47 Right pilot – 47	15,9±1,1	3,0±0,2
	Штурман – 45 Navigator – 45	15,5±1,1	3,0±0,2
	Борттехник – 43 Flight technician – 43	15,2±1,1	2,8±0,2
	Бортрадист – 42 Radio operator – 42	14,8±1,1	2,7±0,2
	Механик грузового отсека – 45 Cargo compartment mechanic – 45	16,0±1,0	2,8 ±0,2
Ми-26 Mi-26	Командир – 28 Commander – 28	22,0±0,9	4,9±0,7
	Правый летчик – 28 Right pilot – 28	20,0±1,1	5,1±0,7
	Штурман – 28 Navigator – 28	19,0±1,2	5,0±0,7
	Борттехник – 25 Flight technician – 25	22,5±1,2	4,5±0,7
	Механик грузового отсека – 26 Cargo compartment mechanic – 26	25,3±2,1	4,5±0,6
Ми-24 Mi-24	Командир – 34 Commander – 34	18,6±1,3	5,1±0,4
	Летчик-оператор – 34 Operator pilot – 34	18,6±1,3	5,1±0,3
	Дозиметрист – 10 Dosimetrist – 10	24,3±2,1	4,5±0,6
	Борттехник – 34 Flight technician – 34	18,7±1,2	5,0±0,3

**Состояние периферической крови у 81 летчика, проходившего обследование в ЦНИАГ
в мае 1986 г.; ноябре 1986 г. – январе 1987 г.; июне 1987 г. – апреле 1988 г.**

Peripheral blood condition in 81 pilots who were examined at the Central Research Aviation Hospital in May 1986;
November 1986 to January 1987; June 1987 to April 1988

Показатель Indicator	Обследованные лётчики без диагноза Examined pilots without a diagnosis			Обследованные лётчики с диагнозом Examined pilots with a diagnosis		
	май / May 1986	ноябрь/Nov 1986 – январь/Jan 1987	июнь/June 1987– апр. /Apr 1988	май / May 1986	ноябрь/Nov 1986 – январь/Jan 1987	июнь/June 1987– апр. /Apr 1988
Гемоглобин, г/л Hemoglobin, g/l	154,2±1,0	150,6±1,0	150,3±1,5	157,5±0,8	152,3±0,9	152,9±0,9
Эритроциты, 10 ¹² /л Erythrocytes, 10 ¹² /l	4,7±0,02	4,6±0,05	4,6±0,05	4,8±0,02	4,6±0,03	4,6±0,03
Ретикулоциты, 0/00 Reticulocytes, 0/00	2,6±0,1	2,7±0,3	2,9±0,4	2,6±0,2	2,4±0,2	2,9±0,4
Тромбоциты, 10 ⁹ /л Platelets, 10 ⁹ /l	277,3±5,1	290,9±8,2	272,0±12,3	284,3±5,4	288,9±5,9	289,0±8,4
Лейкоциты, 10 ⁹ /л Leucocytes, 10 ⁹ /l	6,0±0,1	7,3±0,4	6,6±0,2	6,4±0,2	6,5±0,2	6,4±0,2
Нейтрофилы - палочкоядерные, % Stab neutrophils, %	1,7±0,1	1,7±0,4	1,2±1,2	1,1±0,1	1,0±0,1	1,4±0,2
Нейтрофилы - сегментоядерные, % Segmented neutrophils, %	54,7±0,9	53,7±2,0	53,6±1,3	55,0±1,1	54,1±1,2	53,6±1,1
Эозинофилы, % Eosinophils, %	3,3±0,2	3,1±0,7	3,4±0,4	2,5±0,1	2,9±0,3	2,8±0,3
Базофилы, % Basophils, %	0	0,04±0,02	0,05±0,01	0	0,04±0,03	0,06±0,03
Лимфоциты, % Lymphocytes, %	36,0±0,09	37,3±1,8	36,8±1,5	35,9±0,9	37,1±1,1	36,6±1,0
Моноциты, % Monocytes, %	5,1±0,2	4,1±0,5	4,8±0,5	5,2±0,2	5,0±0,3	5,5±0,3
СОЭ, мм/ч ESR, mm / h	5,0±0,3	5,0±0,5	4,6±0,5	4,8±0,2	4,3±0,3	4,9±0,3

interchangeable lead inserts of 198×77 mm size and 5 mm thickness of each plate was used [1]. In flight, the spatial orientation of the physical protection with respect to the radiation source was taken into account when the pitch angle changed from - 30° to +30° and the roll angle from 20° to

Таблица 3 / Table No. 3

**Доля летчиков с диагнозом до и после пребывания
на ЧАЭС в апреле-мае 1986 г., %, по данным ВЛК**

Share of pilots with the diagnosis, before and after
the Chernobyl accident in April-May 1986, %, according to medical board data

Диагноз по системам Diagnosis by system	До аварии Before the accident		После аварии After the accident	
	1985- 1986	1986- 1987	1987- 1988	
Сердечно-сосудистая система Cardiovascular system	26,0	31,0	32,0	
Желудочно-кишечный тракт Gastrointestinal tract	14,0	17,0	20,0	
Центральная и периферическая нервная система Central and peripheral nervous system	5,0	2,0	6,0	
ЛОП-система / ENT system	3,0	23,0	27,0	
Органы зрения Organs of vision	2,0	6,0	6,0	
Эндокринная система Endocrine system	1,0	1,0	2,0	
Обмен веществ / Metabolism	2,0	7,0	9,0	
Кожа / Skin	3,0	1,0	2,0	
Опорно-двигательная система Musculoskeletal system	1,0	5,0	5,0	
Органы дыхания Respiratory system	1,0	2,0	2,0	
Всего с диагнозом Total with diagnosis	53,0	72,0	75,0	

45°. Model measurements made by our associate A.A. Galkin showed that within these helicopter maneuvering angles, the belt attenuation multiplicity changes insignificantly. Direct measurements of doses in the abdominal area behind the belt during crew operations showed that when physical protection was applied, the radiation dose decreased by a factor of 2 to 3.

During operation, the dose rate in helicopter cabins reached 2-4 Gy/h, and the probability of pilots' overexposure was quite high. Therefore, during the first day of accident elimination the pilots took cystamine in tablets at a dose of 1.2 g after breakfast 40-60 min before the flight. As a result, more than half of the pilots complained of discomfort, nausea and sweating 1 hour after taking cystamine. In this connection the radio-protector indralin — developed by D.I. Mendeleev Moscow Institute of Chemical Technology, the Institute of Aviation and Space Medicine and the Institute of Biophysics of the USSR Ministry of Health — was used instead of cystamine. The drug was manufactured in tablets and provided by the Institute of Biophysics. This drug was used in flights requiring a high level of coordination to stabilize the helicopter while hovering over the "crater" at an altitude of 200 m for 7-20 min. Indralin was taken orally in tablets with a dose of 0.45 g. M.V. Vasin monitored the intake of the drug and the pilots' well-being. After taking the radio-protectant, the crew members did not note any sensations, except for weak manifestations of paresthesia in the face. In their opinion, the drug had no effect on the operator's activity while hovering over the "crater" of the reactor. Laboratory studies performed 7-15 days after the intake of radioprotector during the stay of 7 pilots in Central Research Aviation Hospital did not reveal any functionally significant changes in blood parameters.

From clinical and etiological points of view, the characterization of disease nosology as a disqualifying factor of

Результаты психологического обследования летного состава через 5 лет после выполнения задания на радиационно-загрязненной местности
Results of psychological examination of flight personnel 5 years after a mission in a radioactively contaminated area

Группа Group	Возраст, лет Age, years	Доза облучения, сГр Radiation dose, cGy	Личностная тревожность, ед. Personal anxiety, units	Эмоциональная реактивность, ед. Emotional reactivity, units	Самооценка ночного сна, ед. Self-reported night sleep evaluation, units	Наркологический статус, ед. Drug status, units
1-я 1st	33,9±0,5 (79)	26,2±0,8 (79)	42,8±0,8** (74)	352,4±28,3 (74)	4,8±0,12* (66)	20,7±1,1* (75)
2-я 2nd	34,4±0,7 (41)	14,4±1,1 (39)	39,6±1,3 (35)	273,3±53,9 (16)	5,1±0,12 (41)	17,1±1,13 (40)
3-я 3th	34,4±0,8 (39)	30,8±1,1 (38)	42,0±1,1 (37)	379,8±42,7 (34)	4,8±1,7 (37)	20,5±1,5 (36)
4-я 4th	33,2±1,2 (82)	17,9±0,7 (78)	41,6±0,9 (72)	272,2±57,7 (15)	4,9±0,97 (77)	19,0±0,96 (79)
5-я 5th	32,3±1,1 (28)	–	38,8±1,35 (28)	312,0±24,6 (28)	5,4±0,62 (28)	16,2±1,7 (28)

Примечание: 1-я группа – выполнявшие задание в острый период аварии; 2-я – выполнявшие задание в промежуточный период аварии; 3-я – облученные в дозе более 25 сГр; 4-я – облученные в дозе менее 25 сГр; 5-я группа (контрольная) – необлученный летный состав
Достоверность различий *, ** – между группами 1-й и 2-й, 3-й и 4-й для P<0,05 и P<0,1 соответственно; ± к 5-й группе для P<0,05
В скобках – число обследованных

Note: Group 1 -those who performed the task in the acute period of the accident; Group 2 - those who performed the task in the intermediate period of the accident; Group 3 - those exposed to over 25 cGy; Group 4 - those exposed to less than 25 cGy; Group 5 (control) - unexposed aircrew members
Significance of differences *, ** – between Group 1 and Group 2, Group 3 and Group 3, P<0.05 and P<0.1 respectively; ± to Group 5, P<0.05
In parentheses – number of surveyed

flight personnel is of interest [1, 7, 12, 13]. The nature of the data we obtained confirms the presence of a clear difference between the liquidators and pilots of the control group. Fifteen years of observation showed that in the control group a large proportion of diseases were diseases of the musculoskeletal system. The liquidators group was characterized by the formation of chronic diseases whose pathogenetic mechanism was psychogenic-traumatic. In 1999 35% of helicopter liquidators with a diagnosis were subjected to disqualification due to changes in the neuro-psychic sphere (in the control group – 14%). In addition, the neuropsychiatric component was present in all somatic diseases and even in clinically healthy individuals. A major role in the disqualification of helicopter liquidators is played by cardiovascular diseases (45%), and over 15 years their component has remained virtually unchanged. Thus, in 1986, due to disqualification by disease, the proportion of cardiovascular

disease was 48%, in 1991 - 55%. In the control group in 1986, the proportion of cardiovascular disease in the disqualified population was 55%; in 1991 it was 24%; in 1999 it was only 19%. In 1986, gastrointestinal diseases accounted for 26% of disqualifications in the liquidators and 18% in the control group. By the end of observation disqualification for gastrointestinal diseases decreased to 10%, in the control group – up to 7%. In 1999 in the group of liquidators with diagnoses were disqualified for diseases of the musculoskeletal system – 10%, while in the control group these diseases gave the highest percentage of disqualifications: in 1991 – 24%, in 1999 – 27%.

Flight personnel activities associated with participation in liquidation of the Chernobyl accident took place under conditions of emotional tension and radiation exposure, which pilots had not previously encountered. In addition to external beta- and gamma-exposure, the liquidators were

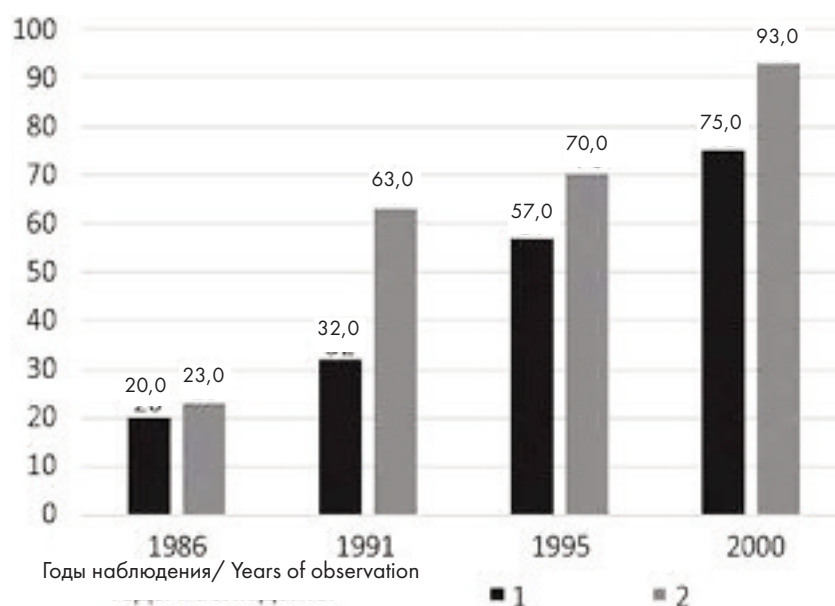


Рисунок. Характеристика общего здоровья ликвидаторов за 15 лет после аварии.

По горизонтали – годы наблюдения; по вертикали – доля (%) летчиков, имевших диагноз заболевания; 1 – контрольная группа; 2 – группа ликвидаторов

Figure. Characteristics of the general health of liquidators in 1986-2000. Horizontal – years of observation; vertical – percentage of airmen diagnosed with disease; 1 – control group; 2 – liquidator group

exposed to internal radiation exposure to alpha-, beta- and gamma-emitting radionuclides incorporated as a result of their inhalation and ingestion into the body during the mission. For example, after the approach of two or three helicopters, a continuous dust cloud at least 30 m high rose over the loading area, and this lasted from April 29 to May 6 for 16 hours a day [3, 4, 7].

In the early period of the liquidation work, the influence of such a stress factor as the fear of overexposure was not excluded. All these factors together determined the subsequent changes in the mental sphere of pilots both in the nearest and in the more distant period. The strength of the impact of emergency radiation environment on the mental state of pilots, including their motivational sphere, is evidenced by the answers to the question: "Is there a desire to take part in similar operations in the future?" Only 23% of respondents answered "yes" affirmatively and without hesitation. The majority (68%) answered "no." In the group of surveyed pilots, 39.5% had an increase in reactive anxiety above 45 units (exceeding the norm 1,5 times), increase of emotional reactivity, decrease of emotional stability level (according to 16-factorial personality survey) and there was vegetative functions liability — increase of tremor, fluctuations of arterial pressure. These shifts in mental status reduce efficiency and reliability of professional activity, affect flight safety and serve as a serious prerequisite for the development of psychosomatic diseases in flight personnel.

At insignificant radiation doses, it is very difficult to differentiate deviations caused by a nonspecific influence of an ex-

treme situation from deviations related to a specific effect of radiation. One can rather speak of a combined effect of emergency factors on the organism of liquidators [1, 12, 14]. And the connection between the value of the dose received and changes in the neuro-emotional state has a unidirectional character. Thus, a positive correlation was noted between the exposure dose and the level of reactive anxiety ($r=0.22$), emotional stability ($r=0.27$) and reactivity ($r=0.46$).

Conclusion

In the nearest period after work in the center of a radiation accident the phenomena of neuroticism were noted in the flying personnel. With the lapse of time the liquidators changed their assessment of the situation of radiation exposure. One year after the accident, 60% of the pilots believed that participation in the events allowed them to believe in themselves, in their strength and abilities; 50% thought that they had acquired professionally important qualities; 30% considered the experience gained valuable; 15% of the pilots after participation in the events gained a new, socially more meaningful outlook on life. In 90.5% of the pilots, participation in the accident elimination did not decrease their motivation for flying work. Almost all of those surveyed were ready to work in such conditions. At the same time, one in three noted that their state of health had deteriorated over the past time, which was expressed in increased fatigability (62.5%) and reduced potency (37.5%). According to the data obtained with the same contingent who did not take part in the Chernobyl events, the disorders were much less widespread.

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