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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**,ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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RESEARCH OF HEMATOLOGICAL CHANGES IN INDIVIDUALS EXPOSED TO IRRADIATION FROM THE CHERNOBYL NUCLEAR POWER PLANT

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Abstract.

The impact of pathogenic factors caused by the consequences of the Chernobyl disaster on the blood system and hemostasis is of great interest. Deviations identified in the first years after exposure to ionizing radiation are primarily restorative and adaptive in nature. This paper presents the results of the monitoring of the changes in each separately studied indicator in the early (1987-1988) and late (2019-2020) periods after the exposure to radiation. Regression equations were obtained that describe the dynamics of changes in certain blood indicators, which make it possible to predict changes over many years after the accident. The hemoglobin and erythrocyte content, compared with the control group (donors), remained within the physiological norm until 1991. A significant decrease in the number of erythrocytes from 1991 to 1997, naturally, should have been reflected in the hemoglobin content, which was manifested in a decrease in their content. In the subsequent years of observations until 2001, a significant decrease in the number of erythrocytes corresponded to a decrease in the hemoglobin content. From 2001 to the present day, the content of erythrocytes and hemoglobin is approaching the boundaries of the physiological norm, albeit with some lag. Changes in blood counts are also influenced by factors that determine a liquidator's susceptibility to certain illnesses. Despite the fluctuating nature of changes in white blood cell counts, an overall trend of decline is nevertheless observed. Stable moderate leukopenia has been observed since 1995. A left shift of granulocytes is observed due to a decrease in the agranulocyte component of blood cells. Thus, it can be concluded that blood cells remain affected by the radiation caused by the Chernobyl accident even at late observation times.

Key words. Ionizing radiation, erythrocytes, hemoglobin, leukocytes, lymphocytes, segmented nucleated cells.

Introduction.

The hematopoietic system, as an actively proliferating tissue, is known to be extremely sensitive to the effects of ionizing radiation. Therefore, the impact of pathogenic factors from the Chernobyl disaster on the blood system and hemostasis is of great interest [1-3]. Analysis of recent literary data on population exposure to low doses of radiation indicates that the early deviations (identified in the first years after exposure to ionizing radiation) are primarily restorative and adaptive in nature [4,5].

According to data from Lyubchenko P.N. et al. [6], at individual doses from 0.02 to 0.37 Gy, most hematological parameters in the examined medical workers at the Chernobyl Nuclear Power Plant returned to normal after 2-3 years, thereby characterizing the limit of physiological fluctuations. Cases of an increase in the number of polymorphonuclear neutrophils, a decrease in the number of lymphocytes and basophils, and an increase in the size of mononuclear cells have been identified. Signs of functional disturbances in the hemostasis at radiation doses of 0.005-0.3 Gy were detected in medical workers at the Chernobyl Nuclear Power Plant after four years of continuous work in the radioactively contaminated zone. The listed effects are most clearly detected using the functional load method.

Materials and Methods.

For the purpose of dynamic observation of Armenian liquidators (men: liquidators group N=2000; control group N=84) of the consequences of the Chernobyl accident, several blood indicators were studied: Hemoglobin (g/l), erythrocytes(10^{12}/l), color index, leukocytes (10^9/l), band neutrop (10^9/l), segmented neutrop (10^9/l), eosinophils (10^9/l), basophils (10^9/l), lymphocytes (10^9/l), monocytes (10^9/l), ESR (mm/h). The study of these indicators among liquidators was carried out using standard unified methods [7-13].

Men in the control group had no contact with the ionization source and were practically healthy individuals. From the very beginning of the research, the average values of the studied indicators differed slightly from the control ones. A variance factor analysis of the data was carried out, which showed that the influence of age ranged from 31% to 38% compared to the radiation factor, which ranged from 42% to 45% (in the long-term period, the influence of age ranged up to 46%). We examined groups that received radiation doses of 10 cGy and 80 cGy.

The regression equations describing the dynamics of changes in these indicators (content: hemoglobin - y1 (g/l), erythrocytes - y2 (10^{12} / l), leukocytes - y3 (10^9/l)) are given:

$y_1=166.79-3.58*x+0.11*x^2$ (hemoglobin)

$y_2=4.84-0.062*x+0.002*x^2$ (erythrocytes)

$y_3=8.07-0.06*x$ (leukocytes)

Where x is the number of years since the accident.

These formulas can be used for forecasting.

The coefficient of determination, which indicates the degree of accuracy of the correspondence between the models and real data in the specified models, is R^2=0.89 to 0.97, $P<0.05$.

The analysis of the data (along with the programs we developed) was conducted using a number of well-known computer programs designed for the statistical processing of digital data arrays. The following were used: a Microsoft Excel spreadsheet [14,15] and specialized statistical packages StatSoft, SPSS, and StatGraphics Plus [16-20].

Results and Discussion.

This study was conducted to dynamically monitor the indicators in Armenian liquidators of the Chernobyl accident. The results

Table 1. *Dynamics changes in blood morphological parameters.*

	Hemoglibin g/l	Erythrocytes 10^{12} /l	Color index	Leukocytes 10^9 /l	Band neutrcph. 10^9 /l	Segmented neutr. 10^9/l	Eosinophils 10^9 /l	Basophils 10^9 /l	Lymphocytes 10^9/l	Monocytes 10^9 /l	ESR mm/h
1987	162,68±0,9	4,96±0,06	0,96±0,02	7,8±0,08	1,26±0,1 7	59,23±0,75	2,4±0,07	0,23±0,06	33,45±0,71	3,28±0,0S	7,26±0,48
1988	164,48±0,7	4,93±0,02	0,99±0,01	8,54±0,11	1,55±0,11	55,28±1,81	2,7 5±0,25	0,07±0,01	37,54±1,53	2,55±0,1	5,07 ±0,2
1989	163,05±0,19	4,86±0,02	0,99±0,01	9,01 ±0,1	1,44±0,08	58,52±0,26	1,95±0,13	0,12±0,04	34,32±0,55	3,48±0,29	4,97 ±0,18
1990	161,25±0,15	4,84±0,01	1,05±0,03	8,73±0,13	1,66±0,03	62,89±0,51	1,68±0,12	0,25±0,07	30,91 ±0,47	3,39±0,09	4,73±0,19
1991	153.95i0.86	4,64±0,04	0,92±0,01	7,38±0,06	0,94±0,07	64,11 ±0,88	1,13±0,07	0,12±0,03	33,39±0,31	3,29±0,11	4,69±0,1
1992	147,01 ±0,2	4,41 ±0,001	0,9±0,01	7,73±0,1	0,95±0,1	61,15±0,31	1,07 ±0,09	0,09±0,01	27,84±0,75	3,7 4±0,49	3,84±0,24
1993	147,09±0,84	4,34±0,1	0,93±0,01	8,03±0,15	0,59±0,02	62,6±1,08	2,44±0,15	0,1 S±0,03	28,22±0,63	5,85±0,28	4,08±0,29
1994	145,84±0,41	4,41 ±0,08	0,92±0,04	8,22±0,16	0,84±0,1	62,69±0,85	2,3±0,18	0,19±0,06	30,35±0,77	5,33±0,16	4,65±0,25
1995	135,12±1,26	4,11 ±0,08	0,91 ±0,003	7,37±0,26	1,59±0,19	60,88±0,62	2,02±0,13	0,28±0,02	30,44±0,47	4,7 4±0,26	5,27 ±0,53
1996	126,33±0,72	3,91 ±0,03	0,92±0,005	6,71 ±0,1	2,5±0,27	57,06±0,53	2,71 ±0,33	0,29±0,05	33,44±0,51	4,05±0,15	6,24±0,4
1997	120,89±0,87	3,76±0,03	0,92±0,004	5,55±0,23	2,56±0,23	59,69±1,55	2.16±0,36	0,34±0,07	31,62±0,67	3,33±0,35	5,46±0,59
1998	146,14±1,41	4,59±0,05	0,91 ±0,009	6,49±0,15	3,2±0,16	59,54±1,46	2,09±0,11	0,33±0,04	30,7 5±1,06	4,07 ±0,25	5,91 ±0,52
1999	138,95±0,98	4,46±0,03	0,92±0,003	6,7 ±0,39	2,67 ±0,21	58,59±0,73	1,82±0,14	0,36±0,05	30,87 ±0,79	5,13±0,25	5,12±0,51
2000	142,14±0,61	4,55±0,01	0,92±0,004	6,97 ±0,13	2,79±0,2	59,53±0,23	2,31 ±0,15	0,52±0,05	29,7 ±0,22	4,53±0,23	5,99±0,39
2001	141,37 ±1,73	4,56±0,05	0,93±0,006	6,78±0,5	2,94±0,12	61,89±1,67	1,74±0,35	0,39±0,1	28,35±0,81	4,27 ±0,46	4,89±0,48
2002	146,27 ±2,1 8	4,59±0,05	0,94±0,01	7,29±0,34	2,89±0,28	56,18±1,11	1,81 ±0,37	0,49±0,13	32,84±0,43	5,27 ±0,42	5,07 ±0,5
2003	139,41 ±2,12	4,84±0,07	0,95±0,05	7,15±0,52	2,55±0,33	60,52±2,31	1,97 ±0,44	0,82±0,01	29,69±1,95	6,14±1,14	6,5±1,11
2004	140,16±3,37	4,5±0,11	0,96±0,01	6,53±0,92	2,71 ±0,51	59,35±5,21	2,25±1,89	0,93±0,01	30,58±3,31	5,87 ±1,85	5,7 5±1,12
2005	147,8±1,01	4,67 ±0,06	0,98±0,05	6,54±0,16	2,57 ±0,14	61,12±0,64	2,99±0,24	1,02±0,02	31,16+0.62	5,25±0,22	6,46±1,31
2006	146,5±3,38	4,77±0,1	1,02±0,01	6,28±0,31	2,28±0,15	62,3±0,85	3,01 ±0,46	1,01 ±0,005	27,82±1,54	5,42±0,51	6,34±1,32
2007	147,2±2,25	4,82±0,07	1,01 ±0,01	7,01 ±0,25	2,35±0,32	61,02±1,53	2,68±0,47	1,01 ±0,01	28,72±1,43	5,51 ±0,46	6,91 ±1,22
2008	148,38±1,26	4,71 ±0,08	0,94±0,009	7,87 ±1,87	2,88±0,35	60,24±1,65	2,91 ±0,56	0,97±0,01	29,07 ±1,41	5,38±0,48	6,31 ±1,99
2009	147,18±1.71	4,69±0,06	0,93±0,006	6,37 ±0,36	2,12±0,22	62,04±1,33	2,26±0,26	1,03±0,04	27,78±1,11	5,94±0,42	9,28±1,47
2010	145,36±2,83	4,51 ±0,1	0,97 ±0,02	6,95±0,31	2,01 ±0,27	61,11 ±1,26	2,87 ±0,304	1,038±0,03	28,01 ±1,19	6,33±0,42	12,87±1,74
2011	157,41 ±2,22	4,92±0,07	0,95±0,006	6,18±0,52	2,5±0,33	57,01 ±2,31	2,07 ±0,44	1,01 ±0,01	30,86±1,95	7,14±1,18	6,5±2,11
2012	161,0±3,37	5,06±0,11	0,95±0,01	6,52±0,92	1,89±0,51	59,8±5,21	3,125±1,89	1,00±0,01	26,9±3,31	8,87 ±2,55	4,75±1,18
2013	151,19±1,01	4,67 ±0,06	0,96±0,005	6,34±0,26	2,38±0,24	62,12±0,94	2,99±0,4	1,03±0,03	28,16±0,82	4,97 ±0,31	9,46±1,38
2014	147,7 ±3,38	4.7 ±0,1	1,01 ±0,01	6,2±0,37	1,88±0,18	63,3±1,55	3,1 ±0,56	1,02±0,001	27,2±1,34	5,4±0,41	7,3±1,32
2015	155,2±2,25	4,8±0,07	1,009±0,001	7,01 ±0,35	2,3±0,37	63,0±1,83	2,6±0,45	1,01 ±0,01	27,2±1,43	5,6±0,46	9,9±1,32
2020	156,0±1,52	4,9±0,05	1,1 ±0,12	6,1 ±0,26	2,0±0,18	63,2±1,29	2,7 ±0,3	1,00±0,01	26,5±1,25	6,2±0,34	11,9±1,14

of monitoring changes in each individual indicator in the early (1987-1988) and later (2019-2020) periods are presented below.

The presented data suggest that relatively low doses of ionizing radiation (0.1-0.3 Gy per year) have a damaging effect on hematopoietic stem cells, resulting in unstable patterns in peripheral blood indicators, as well as structural and functional abnormalities in cellular elements.

It was established that the red blood cell levels in LPA patients did not undergo significant changes in the first 4-5 years after the accident. Hemoglobin and red blood cell levels, compared to the control group (donors), remained within physiological norms until 1991.

The significant decline in red blood cell count from 1991 to 1997 should naturally have been reflected in hemoglobin levels, which was revealed by a decrease in their content, as confirmed by the correlation coefficient between these indicators = 0.93. In subsequent years of observation, up to 2001, a significant decrease in red blood cell count was accompanied by a decrease in hemoglobin levels. From 2001 to the present day, red blood cell and hemoglobin levels have been approaching the physiological norm, albeit with some lag.

In our opinion, the significant drop in the content of red blood cells and hemoglobin, respectively, from 1991 to 1997, cannot be entirely attributed to the long-term effects of low-dose irradiation. During this period, various non-radiation factors may have been superimposed, including social-economic factors, an increase of morbidity in a number of various chronic diseases, and aging of the Armenian liquidators. This is confirmed by the results of a dispersion factor analysis of red blood cells and hemoglobin, carried out dynamically, where an increase in the share of the age factor in these indicators has been observed since 1991 (hemoglobin - from 9.35% in 1987 to 22.42% in 1991; red blood cells - 1.5% in 1987 to 54.75% in 1991).

As our research has shown, changes in blood parameters are also influenced by the factor determining the liquidator's predisposition to a particular disease. Therefore, we also conducted a correlation and regression analysis of the ratio of these parameters in the early period in the general group of liquidators ($y = 47.72 + 21.76x$, where y is the hemoglobin level and x is the red blood cell count; $r = 0.63$) and in the group of liquidators who were diagnosed with cardiovascular pathology (coronary heart disease) 10 years later ($y = 37.83 + 23.91x$; $r = 0.89$). A reliable difference in the leukocyte intoxication index and ESR was also found in these groups. Thus, in the group with cardiac disorders, a significant decrease in the leukocyte index (LII) was observed (0.6±0.075 compared to the group of liquidators without cardiac pathology (0.8±0.07; $p<0.05$) and an increase in the ESR (7.4±0.75 and 9.4±0.67, respectively; $p<0.05$).

Despite the undulating nature of the leukocyte count dynamics, a decline trend is nevertheless observed, described by the

regression formula y=8.07-0.06x (where y is the leukocyte count and x is the number of years since the accident). We have noted stable moderate leukopenia since 1995.

A dynamic study of the leukocyte levels in liquidators showed a significant increase in segmented neutrophils, starting in 1991, with a subsequent decrease by 2002. Nevertheless, according to the regression equation y = 59.65 + 0.05x, where x is the number of years since the accident, a moderate increase in segmented leukocyte levels is expected over the next few years. Lymphopenia was noted throughout the study period. The dynamics of changes in lymphocyte counts are described by the formula y = 33.43 - 0.22x. According to this equation, a further decrease in this indicator is expected. Despite the undulating nature of the changes in band neutrophil counts, an increase in this indicator is observed (y = 1.47 + 0.04x).

Based on the obtained results of assessing the leukocyte count of the liquidators' blood, we studied the granulocyte-agranulocyte ratio, which more clearly demonstrates these changes. It is clear that before 1990, i.e., in the first years after the accident, no changes in the granulocyte-agranulocyte ratio (GAR) were observed in the blood counts of liquidators compared to the donor group. From 1990 to 2000, an increase in the GAR was observed, with a subsequent trend toward normalization by 2005 (this trend is expected in the future, according to the obtained polynomial regression equations).

A left shift of granulocytes was observed due to a decrease in the agranulocyte series of blood cells. The polynomial regression equations obtained were $y1 = 56.92 + 3.08x - 0.15x^2$ and $y2 = 43.917 - 3.2388x + 0.1593x^2$, where y1 is the granulocyte level, y2 is the agranulocyte level, and x is the number of years since the accident.

The peak of the upward change in the GAR occurred in 1994-1995. The mechanism of these redistributions may be related to both the hematopoietic pool, which changes relatively slowly after low-dose irradiation and manifests itself in long-term consequences, and the impact of various non-radiation factors on the liquidators' bodies. These factors may include acquired diseases, socioeconomic factors, increased age, and others, which can dramatically affect blood composition and various parameters. Formed elements of the blood respond to exposure to factors of the Chernobyl accident consequences even at late observation periods. Similar changes have been identified by other researchers [21-23], indicating that the changes we identified in the hematopoietic system of Armenian liquidators are identical.

Conclusion.

Thus, evaluating the results of the studies conducted on the liquidators' peripheral blood and based on the factual material obtained, we can conclude that formed elements of the blood respond to exposure to Chernobyl accident factors even at late observation periods.

Author contributions.

Study Concept and Design: KAG. Acquisition, Analysis, and Interpretation of the Data: KAG, UTR, AEA, PAA, PSS and GVS. KAG and DMH wrote the manuscript. All of the authors have contributed substantially to the manuscript.

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All procedures adhered to relevant ethical guidelines. Participants received full disclosure of experimental requirements, and written informed consent was obtained prior to data collection. This study was conducted in accordance with the experimental protocol that satisfied the provisions of European Communities Council Directive (2010/63/UE). All experiments were approved by the Ethics committee of the Yerevan State Medical University after Mkhitar Heratsi (IRB Expert Conclusion N 10 2/22, 19.05.2022). All methods were carried out in accordance with relevant guidelines and regulations.

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ИССЛЕДОВАНИЕ ИЗМЕНЕНИЙ ПОКАЗАТЕЛЕЙ КРОВИ У ЛИЦ, ПОЛУЧИВШИХ ОБЛУЧЕНИЕ В ЧЕРНОБЫЛЬСКОЙ АЭС

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Резюме.

Проблема влияния патогенных факторов Чернобыльской катастрофы на систему крови и гемостаз представляет большой интерес. Отклонения, выявленные в первые годы после воздействия ионизирующих излучений, носят в основном восстановительный и адаптационный характер. В настоящей работе приведены результаты наблюдения за изменениями каждого отдельно изученного показателя в ранние (1987-1988гг) и отдаленные периоды (2019-2020гг). Получены уравнения регрессии, описывающие динамику изменения некоторых показателей крови, которые дают возможность прогноза изменений на протяжении долгих лет после аварии. Содержание гемоглобина и эритроцитов, по сравнению с контрольной группой (доноры), до 1991 года держалось в пределах физиологической нормы. Достоверное падение количества эритроцитов с 1991г до 1997г, естественно, должно было отразиться и на содержании гемоглобина, что и выявилось в уменьшении их содержания. В последующие годы наблюдений до 2001г. достоверному уменьшению количества эритроцитов соответствовало уменьшение количества гемоглобина. С 2001г. и по сей день содержание эритроцитов и гемоглобина приближается к границам физиологической нормы, однако с некоторым отставанием. На изменение показателей крови влияет и фактор, определяющий предрасположенность ликвидатора к той или иной заболеваемости. Несмотря на волнообразный характер динамики изменения уровня лейкоцитов, тем не менее, прослеживается тенденция к снижению уровня этого показателя. Стабильная умеренная лейкоцитопения отмечена начиная с 1995 года. Наблюдается омоложение гранулоцитов, за счет уменьшения агранулоцитарного ряда клеток крови. Таким образом, можно заключить, что форменные элементы крови реагируют на воздействие факторов аварии на ЧАЭС даже в поздние сроки наблюдений.

Ключевые слова: ионизирующее излучение, эритроциты, гемоглобин, лейкоциты, лимфоциты, сегментоядерные