УДК: 613.648.4:616-073.756.8-036 DOI:10.20969/VSKM.2023.16(suppl.2).43-48

COMPARATIVE EVALUATION OF EFFECTIVE RADIATION DOSES IN PATIENTS AND STAFF IN MEDICAL RADIOLOGY

TASTANOVA GULCHEHRA E., *ORCID ID: 0000-0003-3521-0107, PhD, Associate Professor, Head of the Department of Clinical Human Anatomy, Tashkent State Dental Institute, 103 Maxtumkuli Street, Yashnabad district, 100047 Tashkent, Uzbekistan; tel. +99-871-2302073; e-mail: lolita_yunusova@mail.ru, tastanovage@gmail.com*
LI MARINA V., *ORCID ID: 0000-0001-8533-9852, Dr. sc. med, Associate Professor at the Department of Hygiene and Radiation Safety, Head of the Research Testing Radiological Laboratory Center for Developing Medical Professionals' Vocational Qualifications at the Health Ministry of the Republic of Uzbekistan, 51 Parkent str., 100007 Tashkent, Uzbekistan; e-mail: marina.li@uzliti-en.com*
YUNUSKHODJAEV P., *ORCID ID: PhD, Associate Professor, Department of Clinical Human Anatomy, Tashkent State Dental Institute, Uzbekistan, 100047, Tashkent, Yashnabad district, 103 Maxtumkuli Street, tel. +99-871-2302073; e-mail: pachlavi_yunus@gmail.com*
PARDAEV ANVAR M., *ORCID ID: Assistant Professor Department of Medicine of the Faculty of Medicine, Termez University of Economics and Service, 4 Second Farovon Street, Borgi zaval, 190111 Termez, Uzbekistan; e-mail: anvar_pardayev@tues.uz*
HAIDAROVA BARNOY I., *ORCID ID: Senior Lecturer at the Department of Clinical Human Anatomy, Tashkent State Dental Institute, 103 Maxtumkuli Street, Yashnabad district, 100047 Tashkent, Uzbekistan; tel. +99-871-2302073; e-mail: xaydarova_bi@gmail.com*

Abstract. Introduction. The article presents the findings of the study and comparative assessment of radiation doses in patients and personnel in diagnostic medicine using sources of ionizing radiation. Currently, over 2,373 radioactive sources are used in in 903 medical institutions of the Republic of Uzbekistan. Therefore, an extremely important task is to assess the patients' and personnel risks related to medical and occupational exposure and to create ways to improve radiation protection in medical radiology at the present stage. **The aim** of the study was to perform a comparative analysis of patients' and staff radiation doses used in conducting diagnostic medical procedures involving the sources of ionizing radiation and radioactive substances. **Materials and Methods.** To achieve the goal and objectives of the research aimed at studying radiation doses, we selected protocols for scanning patients during X-ray diagnostics, nuclear medicine studies in medical institutions, and the results of the individual dosimetry monitoring of personnel. **Results and Discussion.** Our findings showed that medical and occupational exposures are within the low to very low dose range and the risks are low to very low, as well. Not only is medical exposure different from other types, but it also carries risks of "no radiation" or "underexposure" that may be greater than the risks of exposure. Limiting medical exposure to only preventive studies (1 mSv) does not solve the problem of reducing medical exposure risks. The concept of "prevention" includes all those who can be classified as "asymptomatic" patients, which is incorrect. People undergoing preliminary or ongoing professional medical examinations do not match with those at risk undergoing, for example, screening studies. The approaches to them should be different. **Conclusions.** In radiation-hazardous medical institutions, all measures must be taken to ensure radiation safety and protection of personnel, patients, the public, and the environment.
Keywords: effective dose, medical exposure, radiation risks, medical sources of ionizing radiation, radiation diagnostics.
For reference: Tastanova GE, Li MV, Yunuskhodjayev P, Pardayev AM, Khaidarova BI. Comparative evaluation of effective radiation doses in patients and staff in medical radiology. The Bulletin of Contemporary Clinical Medicine. 2023; 16(Suppl.2): 43-48. DOI:10.20969/VSKM.2023.16(suppl.2).43-48.

СРАВНИТЕЛЬНАЯ ОЦЕНКА ЭФФЕКТИВНЫХ ДОЗ ОБЛУЧЕНИЯ ПАЦИЕНТОВ И ПЕРСОНАЛА В МЕДИЦИНСКОЙ РАДИОЛОГИИ

ТАСТАНОВА ГУЛЧЕХРА ЕШТАЕВНА, *ORCID ID: 0000-0003-3521-0107, PhD, доцент, заведующая кафедрой анатомии, «Ташкентский государственный стоматологический институт», Узбекистан, 100047, Ташкент, Яшнабадский район, улица Махтумкули, 103, тел. +99-871-2302073; e-mail: lolita_yunusova@mail.ru, tastanovage@gmail.com*
ЛИ МАРИНА ВЛАДИМИРОВНА, *ORCID ID: 0000-0001-8533-9852, докт.мед.наук, доцент кафедры гигиены и радиационной безопасности, руководитель НИИРЛ «Центра развития профессиональной квалификации медицинских работников МЗ РУз», Узбекистан, 100007, Ташкент, ул. Паркентская, 51; e-mail: marina.li@uzliti-en.com*
ЮНУСХОДЖАЕВ ПАХЛАВИ, *ORCID ID: канд.мед.наук, доцент кафедры анатомии «Ташкентский государственный стоматологический институт», Узбекистан, 100047, Ташкент, Яшнабадский район, улица Махтумкули, 103, тел. +99-871-2302073; e-mail: pachlavi_yunus@gmail.com*
ПАРДАЕВ АНВАР МИСИРОВИЧ, *ORCID ID: ассистент кафедры Медицины медицинского факультета «Термезский университет экономики и сервиса», Узбекистан, 190111,Термез, Борги завал, 2-я улица Фаровон, 4; e-mail: anvar_pardayev@tues.uz*
ХАЙДАРОВА БАРНОЙ ИСРАИЛЖАНОВНА, *ORCID ID: старш. преподаватель кафедры Анатомии «Ташкентский государственный стоматологический институт», Узбекистан, 100047, Ташкент, Яшнабадский район, улица Махтумкули, 103, тел. +99-871-2302073; e-mail: xaydarova_bi@gmail.com*

Реферат. Введение. В статье представлены результаты научно-исследовательской работы по изучению и сравнительной оценке доз облучения пациентов и персонала в диагностической медицине при использовании источников ионизирующего излучения. В настоящее время в медицинских учреждениях Республики Узбекистан в 903 организациях используется более 2373 радиоактивных источников. Поэтому в современное время чрезвычайно важной задачей является оценка рисков пациентов и персонала при медицинском и профессиональном облучении с целью создания путей совершенствования радиационной защиты в медицинской радиологии. **Целью исследования** явилось проведение сравнительной оценки доз облучения пациентов и персонала при проведении диагностических медицинских процедур с использованием источников ионизирующего излучения и радиоактивных веществ. **Материал и методы.** Для достижения цели и задач научно-исследовательской работы по изучению доз радиации были выбраны протоколы сканирования больных при общих рентгенологических исследованиях, мультисрезовой спиральной компьютерной томографии, ядерной медицины и результаты индивидуального дозиметрического контроля персонала **Результаты.** Результаты исследования показали, что диагностическое медицинское и профессиональное облучение людей находится в диапазоне доз от малых до очень малых, а риски - от низких до очень низких. Медицинское облучение отличается от других типов радиационного воздействия не только возможность облучения выше нормативных значений, но также несет в себе риски «недостаточного облучения», результатом которого является низкая диагностическая информативность. И данные риски по отношению к здоровью пациентов могут превышать радиационные риски. Ограничение медицинского облучения только за счёт превентивных исследований (1 мЗв) не решает проблему снижения рисков медицинского облучения. В понятие «профилактика» входят все лица, которых можно отнести к «бессимптомным» больным, что неверно. Лица, проходящие предварительный или текущий профилактический медицинский осмотр, не соответствуют лицам группы риска, проходящим, например, скрининговые исследования. **Выводы.** В радиационно-опасных медицинских учреждениях должны выполняться все меры по радиационной безопасности и радиационной защите персонала, пациентов, населения и окружающей среды.

Ключевые слова: эффективная доза, медицинское облучение, радиационные риски, медицинские источники ионизирующего излучения, лучевая диагностика.

Для ссылки: Тастанова Г.Е., Ли М.В., Юнусходжаев П., и др. Сравнительная оценка эффективных доз облучения пациентов и персонала в медицинской радиологии // Вестник современной клинической медицины. – 2023. – Т.16, Прил. 2. С.43-48. DOI: 10.20969/VSKM.2023.16(suppl.2).43-48.

Introduction. The modern understanding of radiation safety is based on 3 basic principles: standardization, justification, optimization. This triad of principles applies to all cases of human exposure to ionizing radiation (IR): artificial radiation, in normal operation of the ionizing radiation sources, emergency, natural, medical. These options differ significantly in the nature of exposure: dose levels, dose rates, duration, geometry of exposure (total, local, scattered, directional), exposure routes (external, internal). For all cases, the resulting dose is the radiation dose, and for effects below the threshold, the effective dose (ED). In turn, the effective dose is a tool for assessing the damage of radiation exposure – stochastic long-term consequences expressed in radiation-induced cases of oncological and genetic diseases. The risks are calculated and amount to approximately 5.5% per 1 Sv and are applied in accordance with the linear- threshold-free concept of the radiation impact on humans.

At present, it is believed that the concept of risk should be extended to all types of exposure. Based on this model, doses from all types of exposure should be reduced by all available means, regardless of the dose range or exposure type, including medical exposure. However, medical diagnostic radiation exposure cannot be compared to any of the types listed, i.e., neither with technogenic nor with emergency, nor with natural ones. MO is very short-term, mainly in the range of very small or small doses, with relatively high dose rates formed discretely and throughout the individual's life.

The purpose of the study is to conduct a comparative assessment of exposure doses to patients and personnel during diagnostic medical procedures using sources of ionizing radiation and radioactive substances.

Materials and Methods. To achieve the goal and objectives of the research work for studying radiation doses, protocols for scanning patients during X-ray diagnostics, nuclear medicine studies in medical institutions and the results of individual dosimetry monitoring of personnel were selected.

Computed tomographs were equipped with the following reconstruction algorithms:

– Back projection (FBR) – a summative reconstruction method traditionally used in computed tomography;

– Iterative reconstruction (iDose) to improve image quality due to high low-contrast resolution and low noise level ("Brilliance iCT 256", "Ingenety Core 128");

– Iterative algorithm of double spaces ClearView with three levels Slight, Standard, Ultra ("NeuViz 16 Essence");

– Iterative model reconstruction (IMR) method for scanning the head, neck, heart, chest, abdomen, pelvis and limbs (Ingenety Core 128, Optima CT 520); and

– Iterative reconstruction algorithm ASiR-5 ("Revolution Discovery CT").

To control individual doses of occupational exposure to category A personnel in Uzbekistan, the dosimetric thermoluminescent complex "DOZA-TLD" is used, manufactured by the Doza Research and Production Enterprise (Russian Federation) in 2003. Thermoluminescent reader and DVG software of this complex are located in the radiological laboratory of the Sanitary Service - Epidemiological Well-Being and Public Health of the Republic of Uzbekistan.

Results and Discussion. In Uzbekistan, the most common medical diagnostic research methods using IRS are fluorography, radiography, fluoroscopy, and computed tomography (CT). To date, there is no unified methodology for assessing the medical exposure risks. Various methods are used, but all of them have drawbacks, are either non-applicable for assessing individual risks or difficult to practice. According to international and national safety standards, the patient must be informed about the received radiation doses and risks.

The average effective doses of radiation per procedure were calculated, the results of which are presented in *Figure 1.*

Figure 2 shows the distribution of effective doses for multislice spiral computed tomography.

Significant differences between the samples were detected using the nonparametric Mann-Whitney U test.

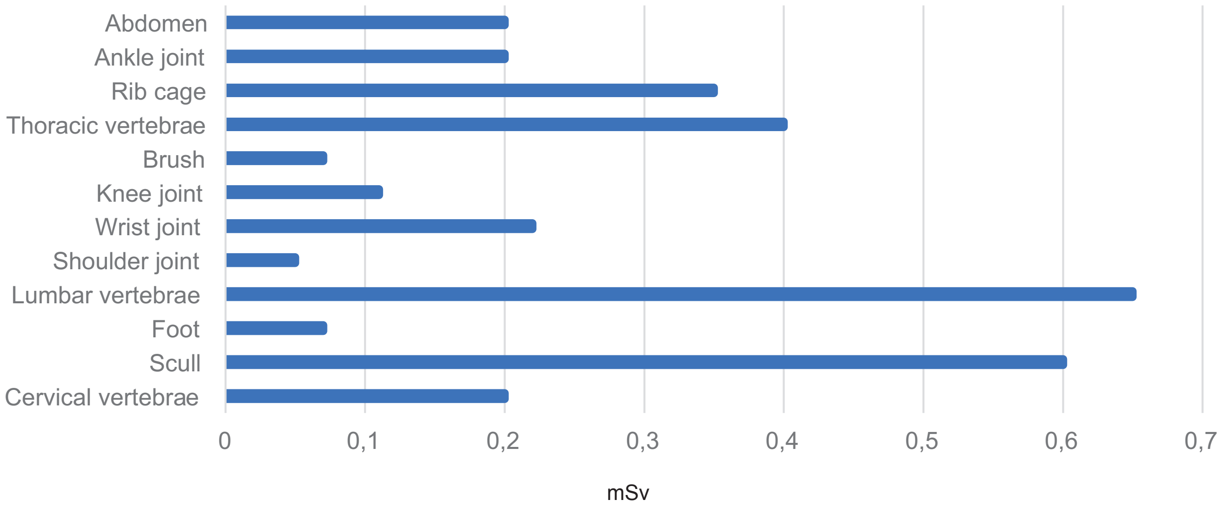

Figure 1. Results of the distribution of average values of effective doses during X-ray examinations
Рис. 1. Результаты распределения средних значений эффективных доз при рентгенологических исследованиях

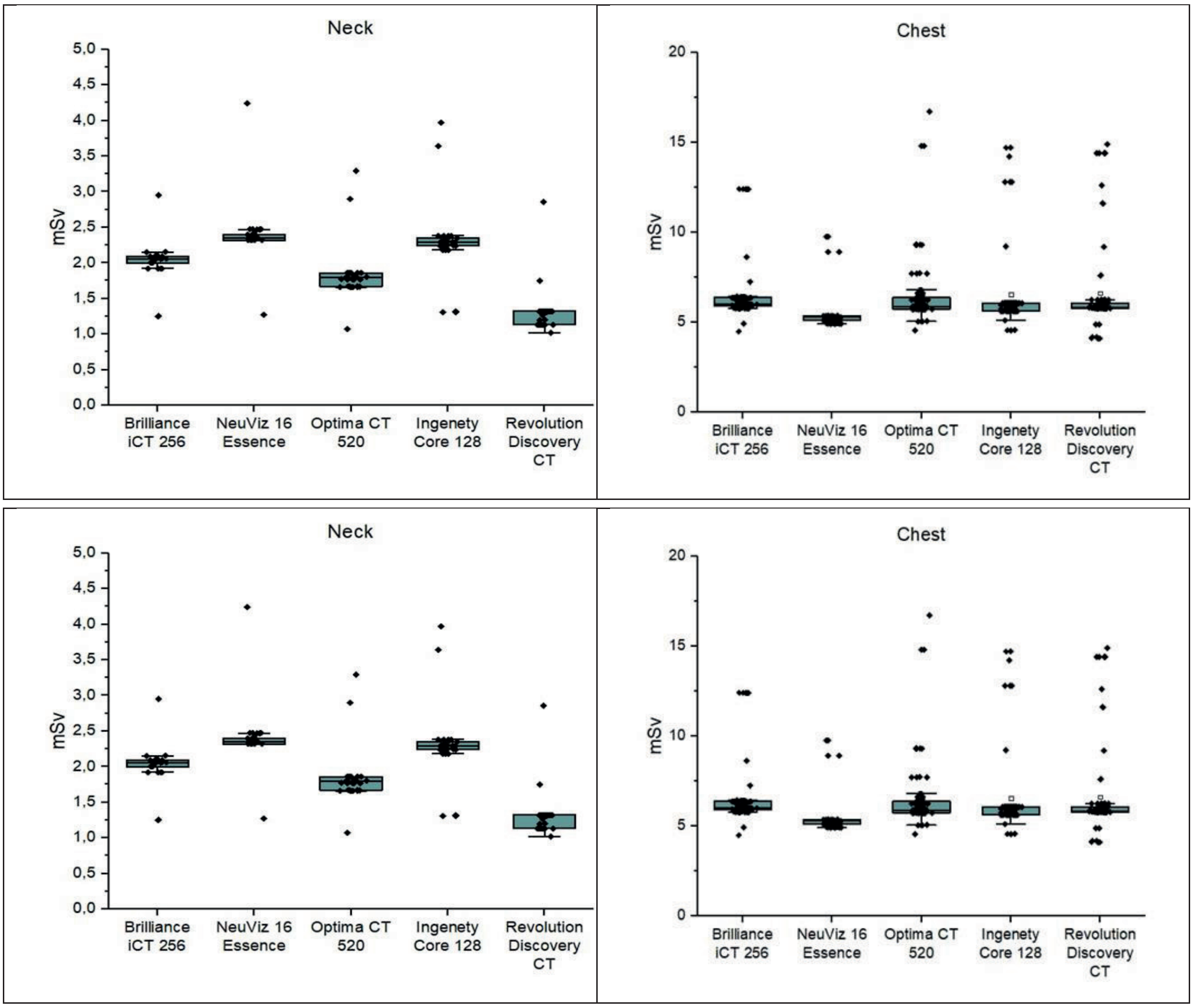

Figure 2. Values of effective doses for different areas of scanning by multislice spiral computed tomography
Рис. 2. Значения эффективных доз облучения пациентов для различных зон сканирования методом МСКТ

The values obtained of the asymptotic significance in the samples are less than 0.05 ($p < 0.05$), which indicates significant differences between the samples.

Since 2018, 3 medical PET/CT centers have been operating in Uzbekistan, which have their own cyclotrons installed to produce short-lived radionuclide F-18 with a half-life of 109 minutes. Next, a radiopharmaceutical (RPh) labeled with F-18 is produced in the synthesis module: Fluorodeoxyglucose (FDG).

When preparing radiopharmaceutical solutions, an individual approach is used, that is, for each patient the drug is prepared individually before the examination starts, in compliance with all sanitary, hygienic, and anti-epidemic rules and regulations in accordance with the GMP standards. If even minor deviations from the synthesis technology are detected, the PET examination will be canceled and rescheduled to another day to guarantee the safety of people.

Nurses inject FDG in patients intravenously, with the required and calculated activity, and then the patients themselves become the ionizing radiation sources (IRS).

Figure 3 shows the average effective doses in patients during positron emission tomography combined with computed tomography (PET-CT).

In Uzbekistan, nuclear medicine is a priority area in oncology, and an important prerequisite for successful development is the production of radionuclides and radiopharmaceuticals by the Institute of Nuclear Physics at the Academy of Sciences. The main advantage of treatment with radiopharmaceuticals is their local selective effect, unlike chemotherapy. *Table 1* presents the results of calculating the average values of effective radiation doses in patients during radioisotope diagnostics using RPh based on radioactive technetium-18.

X-ray diagnostic methods have been and remain widely used in recent decades, although many innovative research techniques have appeared currently. Modern X-ray equipment is also changing for the better; it is becoming more advanced, informative in terms of diagnosis, and safer in terms of radiation doses received by personnel and patients. The results

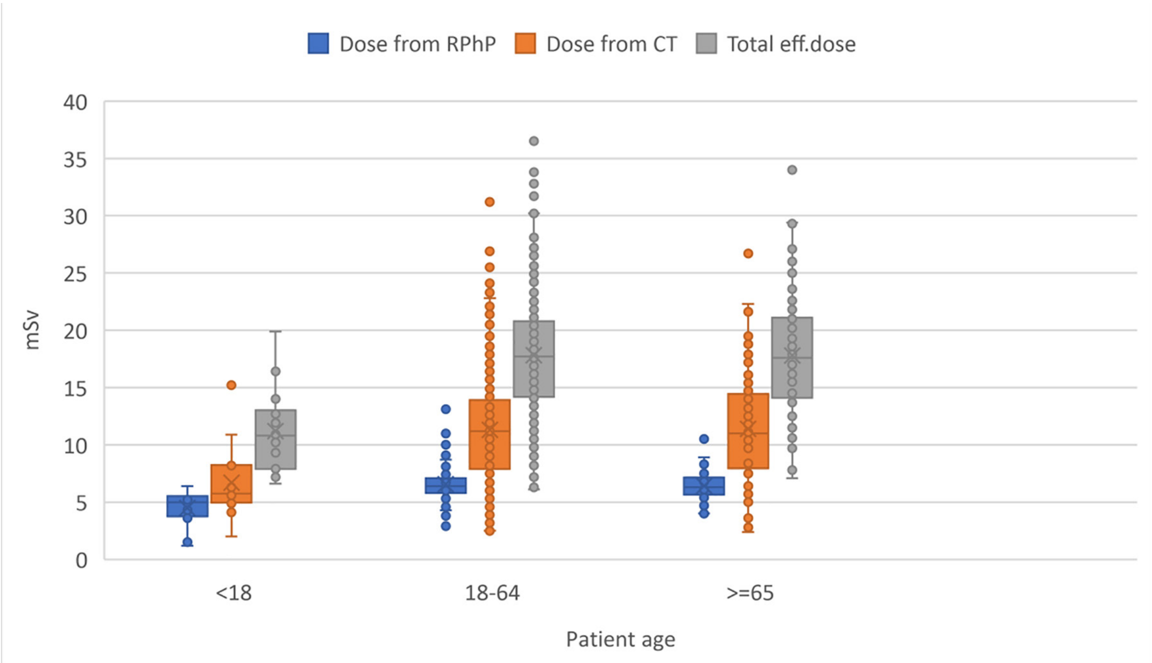

Figure 3. Radiation doses to patients during PET-CT examinations
Рис. 3. Дозы облучения пациентов при проведении ПЭТ-КТ

Table 1

Average values of effective radiation doses in various organs and systems of patients during radionuclide diagnostics

Таблица 1

Средние значения эффективных доз облучения различных органов и систем пациентов при радионуклидной диагностике

Radiopharma-ceutical	Organ/system being examined	Number of patients	Average individual effective doses (mSv)
Technefor	Skeleton	3	4.7±1.8
Pirfotech	Skeleton	973	1.99±0.01
Technetril	parathyroid gland	223	6.25±0.7
Technemag	Kidneys	116	0.7±0.08
Technetium-99 for physical. solution”	Thyroid	2,188	0.29±0.03
Total:		3,503	

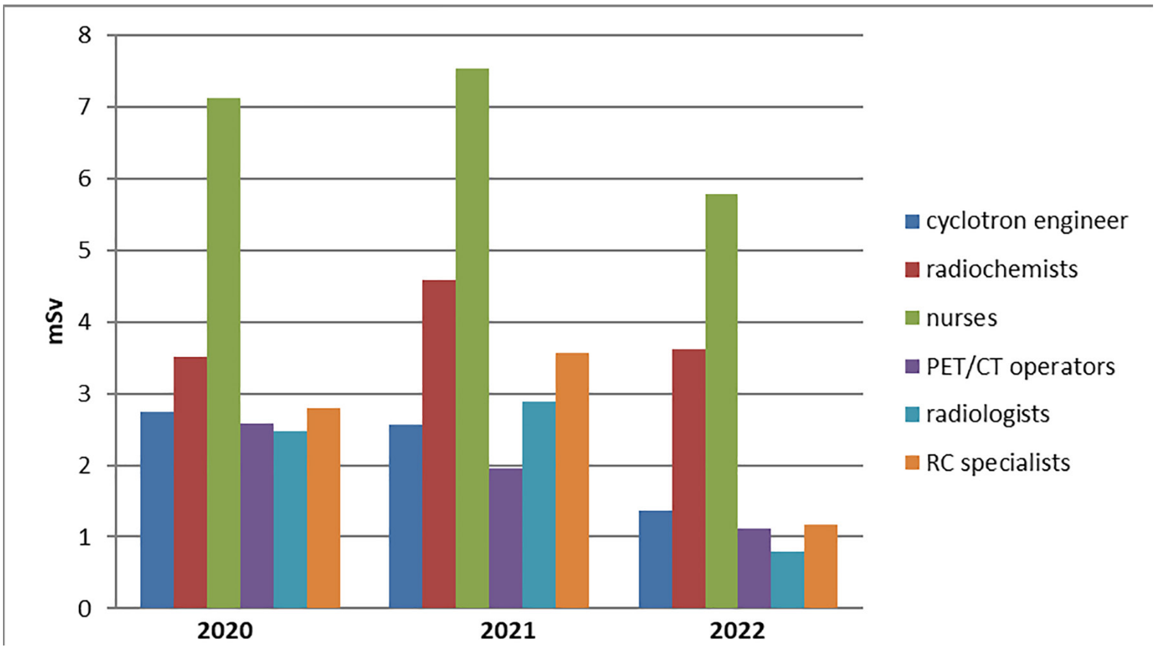

Figure 4. Average values of annual effective radiation doses for workers at nuclear medicine medical centers for 2020–2022
Рис. 4. Средние значения годовых эффективных доз облучения работников медицинских центров ядерной медицины за 2020–2022 гг.

of the study of individual radiation doses in personnel from ionizing radiation generators were within the range of 1.55–2.27 mSv per year.

Figure 4 shows the average values of annual effective radiation doses in personnel at PET/CT medical centers in 2020–2022.

The study results showed that medical and occupational exposures are in the low to very low dose range and the risks are low to very low. Not only is medical exposure different from other types, but it also carries risks of "no radiation" or "underexposure" that may be greater than the risks of exposure. Limiting medical exposure to only preventive studies (1 mSv) does not solve the problem of reducing medical exposure risks. The concept of "prevention" includes all persons who can be classified as "asymptomatic" patients, which is incorrect. Persons undergoing preliminary or ongoing professional medical examinations do not correspond to persons at risk undergoing, for example, screening studies. The approaches to them should be different.

Conclusions. When carrying out diagnostic medical procedures using sources of ionizing radiation and radioactive substances, patients receive the highest doses of radiation during multislice spiral computed tomography. Personnel receive the highest radiation doses when working in direct contact with open radiopharmaceuticals in nuclear medicine. Therefore, at radiation-hazardous medical facilities, all measures must be taken to ensure radiation safety and protection of personnel, patients, the population, and the environment.

Прозрачность исследования. *Исследование не имело спонсорской поддержки. Автор несет полную ответственность за предоставление окончательной версии рукописи в печать.*

Декларация о финансовых и других взаимоотношениях. *Все авторы принимали участие в разработке концепции, дизайна исследования и в написании рукописи. Окончательная версия рукописи была одобрена всеми авторами. Авторы не получали гонорар за исследование.*

ЛИТЕРАТУРА / REFERENCES

1. Samei E, Pelc NJ. Computed Tomography: Approaches, Applications, and Operations. Springer. 2020;469.
2. International Atomic Energy Agency. IAEA human health series № 19: Quality Assurance Programme for Computed Tomography: Diagnostic and Therapy Applications. IAEA: Vienna. 2012; 192. DOI: 978-92-0-128910-0
3. Berkovich GV, Chipiga LA, Vodovatov AV, Trufanov GE. Comparison of different approaches to assessing the diagnostic quality of chest computed tomography. Radiation diagnostics and therapy. 2020; 11(3): 44-55. DOI: 22328/2079-5343-2020-11-3-44-55
4. Berkovich GV, Chipiga LA, Vodovatov AV, Silin AYu, Karatetsky AA, Trufanov GE. Optimization of a low-dose protocol for scanning the chest organs in the diagnosis of ground-glass lesions using iterative reconstruction algorithms. Radiation diagnostics and therapy. 2019; 10 (4): 20-32. DOI: 10.22328/2079-5343-2019-10-4-20-32
5. Kotlyarov PM, Sergeev NI, Solodkiy VA, Soldatov DG. Multislice computed tomography in the early diagnosis of pneumonia caused by SARS-CoV-2. Russian Pulmonology Journal. 2020; 30 (5): 561-568. DOI: 10.18093/0869-0189-2020-30-5-561-568
6. Kotlyarov PM. Post-processing of multislice computed tomography data in the refined diagnosis of pathological changes in diffuse lung diseases. Pulmonology. 2017; 27 (4): 472–477. DOI: 10.18093/0869-0189-2017-27-4-472-477
7. Kotlyarov PM, Yudin AL, Georgiadi SG. Differential X-ray diagnosis of diffuse lung diseases. Part 2: Medical Imaging. 2004; (1): 34–40.

8. Marusina MYa, Kaznacheeva AO. Modern types of tomography. Tutorial. St. Petersburg: St. Petersburg State University ITMO; 2006. 132 p.
9. European Commission. Radiation protection № 180 part, 1/2. Medical Radiation Exposure of the European Population. European Commission: Luxembourg; 2014. 181 p.
10. OECD Indicators. Health at a Glance 2019: OECD Indicators, OECD Publishing. Paris; 2019. 243 p.
11. Sources and effects of ionizing radiation. UNSCEAR Report 2008; 1: 32-34.
12. Golikov VYu, Chipiga LA, Vodovatov AV, Sarycheva SS. Additions and changes in the assessment of effective doses of external radiation to patients in medical research. Radiation hygiene. 2019; 12(43):49-64. DOI: 10.21514/1998-426X-2019-12-3-120-132
13. Kashcheev VV, Pryakhin EA. Medical diagnostic radiation: the problem of radiation safety. Radiation and risk. 2018; 27(4):49–64.DOI: 10.21870/0131-3878-2018-27-4-49-64
14. Mattson S. Need for individual cancer risk estimates in X-ray and nuclear medicine imaging. Radiation Protection Dosimetry. 2016; 169 (1): 11-16. DOI: 10.1093/rpd/ncw034
15. Golikov VYu. Assessment of the risks of medical exposure based on radiation-hygienic certification data in the constituent entities of the Russian Federation. Radiation hygiene. 2015; 8 (4): 4–6.
16. Druzhinina PS, Chipiga LA, Ryzhkov SA, Vodovatov AV, Berkovich GV. Modern approaches to ensuring the quality of diagnostics in computed tomography. Radiation hygiene. 2021; 14(1):17-33. DOI: 10.21514/1998-426X-2021-14-1-17-33
17. Chipiga L.A. Comparison of calculation methods for determining effective and organ doses in patients during computed tomography studies. Radiation hygiene. 2017; 10(1): 56-64. DOI: 10.21514/1998-426X-2017-10-1-56-64
18. American Association of Physicists in Medicine. Performance of Evaluation of Computed Tomography Systems // The report of AAPM N233. 2019. 71 p.