Improving the work environment of medical personnel working with ionizing radioactive sources in Tyumen Region

Gulnur Sulkarnaeva^{1,2}, Elena Bulgakova^{1,2} and Irina Nordman^{2,}*

¹Tyumen State Medical University, Odesskaya, 54, 62500, Tyumen, Russia

²Industrial University of Tyumen, Volodarskogo, 38, 62500, Tyumen, Russia,

Abstract. Modernization of medical equipment with ionizing radioactive sources and introduction of digital technologies as well as computerization of workplaces contribute to the emergence of new non-ionizing factors affecting the health of medical personnel. Analysis of the results of a special assessment of the work environment of medical personnel showed that more than 50% of those work in harmful working environment conditions. According to the results of a special assessment of work environment, 40 workplaces with sources of ionizing radiation with 58 employees were identified in the medical organizations under study. The greatest influence of ionizing radiation was noted among cardio-surgeons and operating nurses of the department of X-ray surgical methods of diagnosis and treatment. On the basis of the performed analysis, recommendations were made to improve the work environment of medical personnel working with sources of ionizing radiation, including air ionization, regulated breaks and uniform distribution of the patients flow during the working day, provision of modern personal protective equipment as well as radiation-measuring control.

1 Introduction

Modern methods of diagnostics and treatment of diseases associated with the use of sources ionizing radiation are widely used in modern medicine. Medical organizations of federal, regional and oblast significance in the Tyumen Region, including the Federal Center for Neurosurgery, the Multidisciplinary medical center "Medical City", the Regional clinical hospital No. 1 etc. are equipped with modern instruments and devices based on the use of various types of ionizing radiation. The main diagnostic and therapeutic methods used in these medical organizations are: positron emission tomography, scintigraphy of various organs and systems, digital fluoroscopy, digital and 3D mammography, conformal radioactive therapy, interstitial radioactive therapy and others. For the implementation of advanced and high-tech research, there are used high-field devices "MPT MRI Siemens Avanto" with magnetic field induction of 1.5T, "GE Discovery MR 750w" with magnetic

*Corresponding author: nordman.i@inbox.ru

field induction of 3.0T, intraoperative mobile computer tomographic scanner "O-Arm" with 3D capability reconstruction and alignment with navigation stations.

The medical personnel performing these diagnostic and treatment methods refers to group A. These are specialists working with ionizing radioactive sources in accordance with radioactive safety standards [1]. In addition, medical and support personnel who do not contact professionally with radio and X-ray diagnostics but located in close proximity are exposed to ionizing radiation in the nature of their duties. These personnel refer the group B.

It should be noted that the introduction of improved methods of radio and X-ray diagnostic studies also the use of low-dose equipment and modern radioactive protection devices significantly reduced the level of exposure of medical personnel. At the same time, according to Russian researchers [2, 3], contact with ionizing radioactive sources within the limits of hygienic standards still depresses the immune system and causes a high incidence rate among radiologists and radiologists, as well as a high level of anxiety for radiologists for their health, which only grows with the increase in the employment term.

In the Russian Federation, an obligatory procedure is carried out to determine the harmfulness and danger of workplaces in medical institutions and all related professions. It is a special assessment of work environment. A special assessment of the work environment of medical workers is held every five years on the basis of the Federal Law No. 426-FZ "On the Special Assessment of Work Environment" [4].

In connection with the modernization of the X-ray equipment park, the introduction of digital technologies and the computerization of workplaces, medical personnel are influenced by new factors of non-ionizing nature, such as air ionic composition, electrostatic and electromagnetic fields of various frequency ranges, visual parameters of video-display terminal, microclimate indicators, high labor intensity etc. [5]. These factors, combined with radioactive exposure, can have an adverse effect on the health of medical personnel.

1.1 Purpose and objectives of the study

The purpose of our study is to develop recommendations aimed at improving the work environment of medical personnel who are constantly or periodically exposed to ionizing radiation in medical organizations of the Tyumen Region.

To achieve this purpose, the following objectives were formulated:

- familiarize with a technique of carrying out of special estimation of work environment in the medical organizations;
- analyze the results of the special assessment of work environment for workplaces of medical personnel working with ionizing radioactive sources in the leading medical centers of the Tyumen Region;
- develop recommendations on optimization of work environment of medical personnel exposed to ionizing radiation.

1.2 Methods

A special assessment of work environment is carried out according to the Methodology approved by Order No. 33n of the Ministry of Labor of the Russian Federation dated 24. of January, 2014 [6] stating that harmful work environment are characterized by the presence of harmful and / or hazardous factors when working with ionizing radioactive sources that do not exceed hygienic standards and are reflected in SanPiN 2.6.1.2523-09 "Norms of radioactive safety [7]. At the same time, the degree of harmfulness (hazard) of work environment is determined not by the degree manifestation of threshold deterministic

effects for working people, but by the increased risk of stochastic no-threshold effects. As a hygienic criterion for assigning the work environment to the class (subclass) of work environment under the influence of ionizing radiation, the power of potential dose of radioactive is the maximum potential effective (equivalent) dose of radioactive that can be obtained in a calendar year when working with sources of ionizing radioactive in standard conditions at a specific workplace [8].

The results of special assessment of work environment in the three leading clinics of the Tyumen region, which have federal (Federal Center for Neurosurgery), regional (Multidisciplinary medical center "Medical City") and territorial significance (Regional clinical hospital No. 1) were considered.

2 Results and discussion

2.1 Results of the study

The analysis of the consolidated statements of the results of the special assessment of work environment in three medical organizations of the Tyumen Region showed that in the Regional clinical hospital No. 1, there is the largest number of jobs (1159) and working personnel (2460), in the Federal Center of Neurosurgery, there is the lowest number of employees (126) and jobs (89) and in the Multidisciplinary medical center "Medical City" there are 166 workplaces with 390 employees.

The distribution of workplaces according to the work environment (Fig. 1) showed that in the Regional clinical hospital No. 1 and the Multidisciplinary medical center "Medical City", there are more than 60% workplaces with harmful work environment, while in the Federal Center for Neurosurgery there is a large part of jobs (84%) corresponding to the allowable work environment (those of the 2nd class).

Fig. 1. Distribution of workplaces in medical organizations by classes of work environment.

Analysis of the distribution of working personnel according to the classes of work environment in the medical organizations under study, shown in Figure 2, demonstrates that 70% of the employees in the Regional clinical hospital No. 1, 68% in the Multidisciplinary medical center "Medical City" and 27% in the Federal Center for Neurosurgery work in hazardous work environment.

Moreover, about half of the workplaces and working staff of the regional clinical hospital No. 1 and the multidisciplinary "Medical City" have work environment corresponding to the harmful class of the second degree of harm (3.2).

Fig. 2. Distribution of working personnel in medical organizations by classes of work environment.

Based on the results of the special assessment of work environment, 40 workplaces with ionizing radioactive sources were identified in the medical organizations under study, with 58 employees working there.

The analysis of the distribution of workplaces with ionizing radioactive sources according to the classes of work environment in the medical organizations under study is shown in Figure 3. The distribution of medical personnel exposed to ionizing radioactive, according to the classes of work environment, is shown in Figure 4.

According to the results of a special assessment of work environment in Regional clinical hospital No. 1, cardiovascular surgeons and operating nurses of the department of X-ray surgical methods of diagnosis and treatment are exposed to the greatest effect of ionizing radiation (class 3.2). In addition, all workplaces of medical and paramedical personnel of the department of X-ray surgical methods of diagnosis and that of radioactive diagnostics are estimated by the biological factor as class 3.2.

It should be noted that harmful work environment (class 3.1), caused by exposure to ionizing radiation, have been identified at workplaces of maintenance personnel engaged in cleaning the rooms of the department, as well as engineering and technical personnel

involved in setting up and repairing equipment at the Regional clinical hospital No. 1 and Multidisciplinary medical center "Medical City".

Fig. 3. Distribution of workplaces of medical personnel working with ionizing radioactive sources by classes of work environment.

Fig. 4. Distribution of medical personnel working with ionizing radioactive sources by classes of work environment.

2.2 Findings and recommendations

The analysis of the results of a special assessment of work environment showed that the class of work environment was defined by 35 employees as 3.2 and by 7 employees as 3.3. That is, work environment is characterized by such levels of harmful factors, which impact leads as a rule to the development of occupational diseases of mild and moderate severity during employment term as well as to the growth of chronic pathology, including increased levels of morbidity with temporal disability.

Accordingly, the recommendations developed by us include measures to improve work environment.

The first recommendation presupposes the installation of an air ionizer (bringing air ions to the required level), since at workplaces with sources of ionizing radioactive, it is important to neutralize positive ions with the help of ionizers. The rationale for this recommendation can be found in the studies of A.L. Chizhevsky and his followers, who found that negative ions of oxygen, obtained with the help of air ionizers, have a beneficial effect on the state of the nervous system, blood pressure, tissue respiration, metabolism, the physicochemical properties of blood, the ratio of protein plasma fractions, hematopoiesis, blood sugar, electrokinetic potential of erythrocytes, mitogenetic mode of tissues and isoelectric points of tissue colloids. Such universality of the physiological action of negative oxygen ions, A.L. Chizhevsky explains that they affect the basic electro-exchange and physicochemical processes, normalizing their intensity [9].

To reduce the adverse effects of stress on the radiologist and X-ray laboratory technician, it is recommended to establish regulated breaks [10] and a uniform distribution of the patients flow during the working day.

Over a number of decades, personal protective equipment for personnel has been limited to the use of protective means from lead rubber, characterized by a lack of flexibility, heavy weight and toxicity.

On the other hand, the use of standard personal protective equipment limits the mobility of medical personnel. In this regard, employees do not most often use individual protective equipment during the procedures. Hence, the primary task is the creation of new personal protective equipment that is free from these shortcomings. The fulfillment of this task was possible only with the implementation of a number of technical problems: provide employees with certified personal protective equipment.

Therefore it has been proposed the use of personal protective equipment made of multilayer polyvinyl chloride, which is more lightweight and does not emit lead dust.

The radiation-measuring provision of medical personnel is limited to the wearing of individual dosimeters primarily at the breast level. Calibration of these dosimeters is carried out in units of exposure and absorbed doses. At the same time, in world practice and in our country it is customary to use the effective dose criterion [11], which has not been adequately evaluated for the personnel of X-ray diagnostic rooms to date.

So, as the workplaces of the department of X-ray surgical methods of diagnostics and that of radioactive diagnostics of Regional clinical hospital No. 1 were estimated by the biological factor as class 3.2., it is recommended the compliance with the requirements of the hospital hygiene and infection control.

Thus, we consider the need to introduce these recommendations into the production process of the Regional clinical hospital No. 1 and the Multidisciplinary medical center "Medical City", as well as in the future also to the practice of other medical organizations in our region, which implementation will:

- reduce the radioactive doses for medical personnel;
- reduce the severity and the work intensity of medical staff;
- eliminate the harmful effects of lead dust on the health of working personnel.

References

1. *Russian Standard SanPiN 2.6.1.2523 – 09* (2017)
2. M.M. Vlasova, V.M. Shubik, *Successes of gerontology* **25-3**, 517-524 (2012)
3. V.V. Kosarev, S.A. Babanov, *Medical almanac* **3(12)**, 18-21 (2010)
4. Federal Low No. 426-FZ (2017)
5. E.V. Bulgakova, D.I. Shipitsina, S.A. Kudryavtsev, O.V. Sentsov, G.A. Sulkarnaeva, *Modern Trends in Science and Education*, **497-503** (2017)
6. *Order of the Ministry of Labor of Russia No.33n: Methodology of evaluation. Classification of harmful industries, the form of the report on the evaluation and the Instruction for its completion* (2017)
7. *Russian Standard SanPiN 2.6.1.2523 – 09*.
8. Order of the Ministry of Labor of Russia No. 33n (2014)
9. V.P. Skipetrov, *Aeroions and life*, **136** (2005)
10. *Radiation Safety Manual for nursing staff* (University of Virginia, 2016)
11. S.L. Simon, *Health Physics* **101(1)**, 13-27 (2011)