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ORIGINAL PAPERS

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PERSONAL DOSE EQUIVALENT Hp(0.07) OF MEDICAL PERSONNEL OCCUPATIONALLY EXPOSED TO IONIZING RADIATION DURING 2001–2011

OCENA WIELKOŚCI INDYWIDUALNYCH RÓWNOWAŻNIKÓW DAWEK Hp(0,07) U PRACOWNIKÓW MEDYCZNYCH ZAWODOWO NARAŻONYCH NA DZIAŁANIE PROMIENIOWANIA JONIZUJĄCEGO W LATACH 2001–2011

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Abstract

Background: The paper presents the results of the determinations of the personal dose equivalent Hp(0.07) received by medical employees of interventional radiology departments occupationally exposed to X and gamma rays in Poland in 2011, performed by the Nofer Institute of Occupational Medicine in Łódź. The results were compared with the data collected during the last decade. **Materials and Methods:** The dosimetric service was provided for medical employees of interventional radiology departments occupationally exposed to ionizing radiation in terms of the personal dose equivalent Hp(0.07). In 2011, personal dosimetry Hp(0.07) determinations performed by the Nofer Institute of Occupational Medicine in Łódź covered 2017 workers employed in 159 medical laboratories. The determinations were performed using ring dosimeters equipped with thermoluminescence detectors according to the procedure accredited by the Polish Centre for Accreditation (document number AB 327). The determinations were carried out in one or two-month periods. **Results:** Mean annual personal dose equivalent Hp(0.07) in 2011 was equal to 4.9 mSv (annual limit for Hp(0.07) is 500 mSv). The mean annual doses of Hp(0.07) varied from 7.6 mSv in 2001 to 5.6 mSv in 2010. In 2011, two cases of exceeding the annual dose limit of Hp(0.07) were reported. The results show that more than 95% of all examined annual doses did not exceed the level of 10 mSv. **Conclusions:** The comparison of the average annual doses and detailed distributions of the doses during the last few years suggests a stabilized level of occupational exposure and an acceptable level of radiological protection in interventional radiology departments monitored by NIOM in Łódź. Med Pr 2012;63(6):623–627

Słowa kluczowe: photon radiation, personal dose equivalent, thermoluminescence detector, interventional radiology, extremity dosimeter

Streszczenie

Wstęp: W prezentowanej pracy przedstawiono wyniki oceny indywidualnych równoważników dawek Hp(0,07) promieniowania jonizującego u medycznych pracowników zakładów radiologii interwencyjnej zawodowo narażonych na promieniowanie rentgenowskie i gamma w Polsce w roku 2011 przeprowadzonych przez Zakład Ochrony Radiologicznej Instytutu Medycyny Pracy im. prof. J. Nofera w Łodzi. Ponadto porównano otrzymane wyniki z danymi zgromadzonymi w bazie w ciągu ostatniego dziesięciolecia. **Materiał i metody:** Pomiary dozymetryczne dla pracowników zakładów radiologii interwencyjnej zawodowo narażonych na promieniowanie jonizujące prowadzono na podstawie pomiarów indywidualnego równoważnika dawki Hp(0,07). W 2011 r. Instytut Medycyny Pracy w Łodzi obejmował pomiarami 2017 osób zatrudnionych w 159 placówkach służby zdrowia. Badania wykonywano techniką dozymetrii termoluminescencyjnej zgodnie z procedurą badawczą akredytowaną przez Polskie Centrum Akredytacyjne (zakres akredytacji AB 327). Pomiary indywidualnego równoważnika dawki Hp(0,07) wykonywane są w sposób ciągły w cyklach 1- lub 2-miesięcznych. **Wyniki:** Średni roczny indywidualny równoważnik dawki Hp(0,07) w 2011 roku wynosił 4,9 mSv (roczny limit dawki dla Hp(0,07) wynosi 500 mSv). Średnie wartości rocznych indywidualnych równoważników dawek Hp(0,07) zmieniały się od 7,6 mSv w roku 2001 do 5,6 mSv w 2010. W roku 2011 odnotowano dwa przypadki przekroczenia rocznego limitu dla Hp(0,07). Dane zgromadzone w bazie wskazują, że ponad 95% wszystkich rocznych dawek Hp(0,07) nie przekroczyło poziomu 10 mSv. **Wnioski**: Porównanie zebranych w bazie wyników średnich rocznych dawek Hp(0,07) w roku 2011 oraz analiza tych danych w odniesieniu do ostatniego 10-lecia wskazuje na ustabilizowany poziom narażenia zawodowego powodowanego promieniowaniem X i gamma w zakładach radiologii interwencyjnej monitorowanych przez Instytut Medycyny Pracy w Łodzi. Med. Pr. 2012;63(6):623–627

Key words: promieniowanie fotonowe, indywidualny równoważnik dawki, dozymetr termoluminescencyjny, radiologia interwencyjna

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The study carried out under the theme realized by NIOM "Dozymetria pierścionkowa" ("Ring dosimetry"). Project manager: Marek Zmyślony, associate professor at NIOM.

INTRODUCTION

During the last few decades, a wide range of medical applications and procedures using ionizing radiation has been observed, with the resultant increased occupational exposure of some medical workers like radiologists, physicians, technicians, nurses and others. Obviously, the doses received by medical staff differ depending on the type of the procedure and the medical source of ionizing radiation. The most occupationally exposed group (especially in terms of their hands) among all the medical staff are doctors performing medical interventional procedures (1).

One of the basic elements of the system of radiation protection for people occupationally exposed to radiation has been introduced where, in contrast to the medical exposure, the system of limitation of the annual doses has been provided by relevant regulations (2). The requirement of the individual monitoring of all workers occupationally exposed to ionizing radiation will depend on the radiation conditions. That is why, for the medical staff involved in interventional procedures, a whole-body dosimetry is not sufficient (3). According to the national regulations, an additional dosimeter for the skin of the hands is required (4).

The assessment of the occupational exposure of the medical staff performing interventional radiology procedures in Poland has been performed, in accordance with the national regulations, among others by the dosimetry service of the Department of Radiation Protection of the Nofer Institute of the Occupational Medicine in Łódź (NIOM) since 2001. Our Institute is one of several officially accredited monitoring laboratories in Poland. The employee exposure assessment is performed on the basis of determinations of individual doses expressed in terms of individual dose equivalent Hp(0.07). The determinations are performed using ring dosimeters worn by selected workers for periods ranging from one to two months. So far, in total, about 100 thousand records of doses have been collected.

MATERIALS AND METHODS

The measurements are carried out with the use of dosimeters in the form of finger rings equipped with two thermoluminescence detectors (TLD Poland, Kraków) without any filters. The NIOM ring design has been developed specifically for dosimetric purposes. A dosimeter ring is made of flexible plastics, with the diameter of approximately 20 mm, and it can be placed under the surgical gloves on any finger of the leading hand performing the procedure.

Thermoluminescence dosimetry uses the ability of certain materials to emit light from the crystal when heated as a result of exposure to ionizing radiation. The amount of emitted light is dependent upon the exposure and it is proportional to the dose. The dosimetry is based on standard thermoluminescent detectors MTS-N (LiF: Mg, Ti) sintered in the form of pellets with a 4.5 mm diameter and 0.9 mm thickness. The main features of the TL detectors are: adequate sensitivity, low background and tissue-equivalence. A very important feature of these detectors is that they are exchangeable with other well-known phosphors and pellets commonly used in many laboratories. The detectors are read out in a manual TL reader model RA94 (MIKROLAB, Kraków, Poland) according to the standard conditions recommended by the manufacturer and the accredited procedure. The whole process of determination is controlled by the dedicated computer software.

The assessment of the personal dose equivalents Hp(0.07) is performed in one-month or two-month cycles in the ranges of energy and doses equal to (24–1250) keV and (0.05–5000) mSv, respectively. The dosimeters are worn by the medical staff in a continuous manner during the medical procedures. In 2011, personal dosimetry Hp(0.07) determinations performed by NIOM covered 2017 workers employed in 159 medical laboratories.

RESULTS AND DISCUSSION

Table 1 presents the summary of the personal dosimetry results collected by NIOM. The measurements of the doses to the skin of the hands were commenced at NIOM in 2001. At the beginning, the determinations of the personal dose equivalent Hp(0.07) covered only 170 people from 27 medical departments. Over time, the number of people was systematically increasing and, finally, in 2011, it embraced 2017 people (from 159 medical departments). Table 1 shows (with the accuracy of 0.1%), the percent distribution of all the registered values of the personal dose equivalents Hp(0.07) with the average value for each year shown separately. The mean doses range from 3.8 mSv to 17.9 mSv during consecutive 11 years and it can be noticed that the number of reported doses below 10 mSv is from 78 to 96 %. In comparison with other dosimetric services in Europe performing the measurements of Hp(0.07) using the same type of dosimeters, in 2005, the range of the mean annual dose was from 2.3 mSv to 19.2 mSv (5), while in the same year, according to the data gathered by NIOM, it was equal to 5.7 mSv.

Table 1. Distribution of individual dose equivalents Hp(0.07) in health care workers occupationally expose to X and γ radiation during 2001–2011
Tabela 1. Rozkład indywidualnych równoważników dawek Hp(0,07) w populacji pracowników służby zdrowia zawodowo narażonych na promieniowanie X i γ w latach 2001–2011

Year Rok	Workers Pracownicy [n]	Laboratories Zakłady [n]	Mean dose Średnia dawka [mSv]	People receiving an annual dose within the specified range* Osoby, które otrzymały roczną dawkę w poniższych zakresach* [%]						
				[0.05–10] mSv	(10–20] mSv	(20–50] mSv	(50–100] mSv	(100–200] mSv	(200–500] mSv	> 500 mSv
2001	170	27	7.6	86.0	6.6	3.5	3.1	0.4	0.4	0.0
2002	204	29	17.9	81.0	11.0	5.0	2.0	0.5	0.5	0.0
2003	330	42	8.7	83.0	5.4	5.8	3.6	0.9	1.3	0.0
2004	521	52	9.8	87.7	5.0	3.0	1.4	1.9	0.0	1.0
2005	728	59	5.7	89.5	5.1	3.7	1.0	0.6	0.1	0.0
2006	805	62	7.5	78.0	8.0	13.0	0.9	0.0	0.0	0.1
2007	999	83	6.5	93.5	2.8	2.3	0.6	0.4	0.4	0.0
2008	1 396	113	5.6	93.3	3.1	2.1	0.7	0.6	0.2	0.0
2009	1 609	162	3.8	94.6	2.4	2.0	0.7	0.2	0.1	0.0
2010	1 845	152	5.6	94.6	1.7	2.1	0.5	0.6	0.5	0.0
2011	2 017	159	4.9	96.0	1.3	1.6	0.2	0.4	0.4	0.1

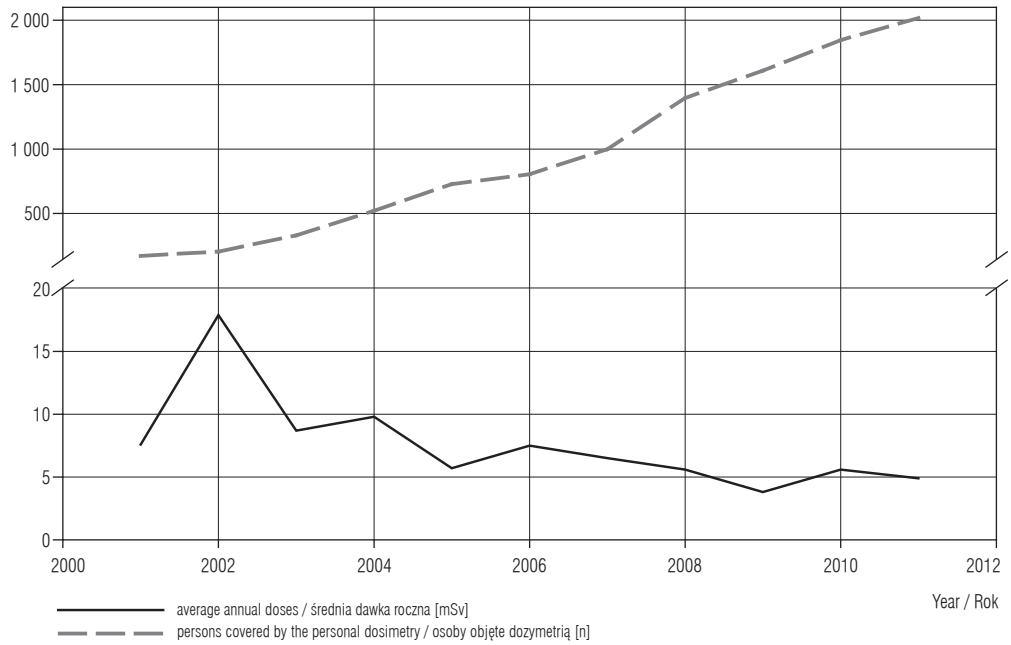
* The total number of cases of exceeding the annual limit of the individual dose equivalent Hp(0.07) during 2001–2011 is equal to 8 / Łączna liczba przypadków przekroczenia rocznego limitu indywidualnego równoważnika dawki Hp(0.07) w latach 2001–2011 wynosi 8.

It can be observed that the average annual dose Hp(0.07) in 2011 was equal to 4.9 mSv and, in comparison with the previous six years, it did not change significantly. Comparing the mean doses (presented in Table 1) derived from the above-mentioned interval with the data reported by NIOM for the first four years of performing the measurements of the doses to the hands, it can be seen that these values (with the maximum value of 17.9 mSv in 2002) are much higher. This indicates that the trend of exposure shows dose reduction. The apparent discrepancies between the reported values in those two intervals can be explained most likely by the fact that since 2006, the monitoring of radiation exposure to the skin of the hands has been mandatory according to the national regulations (4), which contributed significantly to the radiation protection programmes implemented first of all at the workplaces in interventional radiology and cardiology.

Figure 1 illustrates the growing trend of the number of persons covered by the personal dosimetry Hp(0.07) measurements. In addition, on the same figure, the trend of exposure demonstrates the annual dose reduction occurring in the subsequent years from 2001 to 2011.

Furthermore, in 2011, only two cases of exceeding the annual dose limit of Hp(0.07) were reported per 2017 people (the annual limit for Hp(0.07) is 500 mSv (2)), which is presented in Table 1. In addition, the results show that over 95% of all the examined annual doses did not exceed the level of 10 mSv. The analysis of the number of cases of exceeding the relevant annual dose limit since 2001 indicates that the excessive doses occurred sporadically, i.e. 8 cases were recorded over 11 years.

The medical personnel that performs the diagnostic and therapeutic procedures in the field of interventional radiology and interventional cardiology is considered to receive the highest exposures, especially to the



Źródło: non-published data of Nofer Institute of Occupational Health, Łódź / niepublikowane dane Instytutu Medycyny Pracy im. prof. J. Nofera w Łodzi.

Fig. 1. Medical staff covered by the personal dosimetry Hp(0.07) and the mean doses during consecutive years from 2001 to 2011
Ryc. 1. Pracownicy służby zdrowia objęci pomiarami indywidualnych równoważników dawek Hp(0,07) oraz średnia roczna dawka zmierzona w latach 2001–2011

extremities, among any staff working with the medical X-ray techniques. Occupational exposure assessment of the medical staff is very difficult to conduct, as the absorbed doses might vary a lot even while performing the same type of procedures. There are many factors affecting the extremity doses, such as: complexity of the procedure, X-ray geometry and spectra, applied protective devices, etc.

The analyses of the extremities dose measurements during medical procedures are widely reported in the literature. Generally, finger doses are measured using the same detectors as those used by NIOM i.e. thermoluminescent detectors. Unfortunately, some studies report only the results of the doses measured for one specific procedure. Analyzing this group of studies on interventional radiology and/or cardiology procedures, it can be stated that finger doses: (109–614) μSv per procedure (6), (120–840) μSv per procedure (7,8) and (260–350) μSv per procedure (7–11) and maximum doses 7.3 mSv per procedure (12) were reported. In others studies, attempts were made to estimate the annual dose received by the medical staff with regard to the number of procedures performed in the indicated year. According to the literature, the annual doses to the fingers estimated for the operators differ from one another e.g.: Koukorava et al. (13) reported 90.4 mSv, while Domienik et al. (14) estimated the maximal annual doses at the level of 205 mSv and 355 mSv. In addition, Krim et al. (15) reported that the annual estimated finger doses of 3 medical workers out of 84 were found to exceed 3/10th of the annual limit. To sum up, it can be stated that our results are consistent with the data reported in the literature.

The results presented in the current manuscript and the also in the cited papers show that all the recorded results were below the established dose limit. However, the differences in the doses received by the medical staff might be significant. Therefore, extremity (fingers/hands) monitoring is necessary, especially in case of all interventional procedures.

CONCLUSIONS

In the current study, an analysis of the hand doses received by the medical staff during interventional procedures has been reported. The presented comparison of the average doses and the distributions of the doses to the hands of the people occupationally exposed to X-ray and γ radiation confirms a stable level of exposure and a satisfactory state of radiological protection in interventional radiology facilities in Poland monitored by NIOM.

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