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Evaluation of exposure and awareness of radiation in healthcare professionals exposed to ionizing radiation

İyonlaştırıcı Radyasyona Maruz Kalan Sağlık Çalışanlarında Radyasyon Maruziyeti ve Farkındalığının Değerlendirilmesi

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ABSTRACT

Aim: To evaluate radiation exposure and awareness of radiation in healthcare professionals exposed to ionizing radiation.

Material and Methods: The study was carried out at the Alanya Alaaddin Keykubat University Training and Research Hospital and the Süleyman Demirel University Hospital. Physicians, nurses, paramedics, anesthesia technicians, caregivers and cleaning staff exposed to radiation, participated in the study. An inquiry form was prepared to carry out the study, in which the demographic characteristics of the healthcare professionals, the characteristics related to the radiation they were exposed to, the effects that may occur due to this exposure were asked; the relationship between these was statistically analyzed according to the answers.

Results: One hundred twenty-nine healthcare professionals, 81 men and 48 women, participated in the study. Most of the healthcare professionals exposed to radiation have been working for more than 10 years and at a distance of less than 3 meters to the radiation source. Thirty-two of the participants (24.8%) did not use any personal protective equipment. On the day of exposure to radiation, 91 persons (70.54%) were experiencing symptoms such as weakness, fatigue, and headache, unlike other days. It was determined that personal protective equipment use did not correlate to education levels and radiation training background.

Conclusion: Most of the healthcare professionals exposed to radiation have not previously received any training on radiation and do not use personal protective equipment regularly. This situation causes these persons to complain of weakness, tiredness or headaches at the end of the day.

Keywords: Radiation, ionizing radiation, questionnaire, X-ray, computed tomography

ÖZ

Amaç: İyonize radyasyona maruz kalan sağlık çalışanlarında radyasyon maruziyeti ve farkındalığını değerlendirmek.

Gereç ve Yöntem: Çalışma Alanya Alaaddin Keykubat Üniversitesi Eğitim ve Araştırma Hastanesi ve Süleyman Demirel Üniversitesi Hastanesi'nde gerçekleştirildi. Çalışmaya radyasyona maruz kalan hekimler, hemşireler, sağlık memurları, anestezi teknisyenleri, hasta bakıcıları ve temizlik personelleri katıldı. Çalışmayı gerçekleştirmek için bir sorgulama formu hazırlandı. Bu formda çalışanların demografik özellikleri, maruz kaldığı radyasyon ile ilgili özellikler, bu maruziyete bağlı oluşabilecek etkiler soruldu ve cevaplara göre aralarında ilişki olup olmadığı istatistiksel olarak incelendi.

Bulgular: Çalışmaya 81 erkek, 48 kadın olmak üzere 129 sağlık çalışanı katıldı. Radyasyona maruz kalan sağlık çalışanlarının çoğu 10 yıldan daha uzun süredir ve radyasyon kaynağına 3 metreden daha yakın mesafede çalışmaktaymış. Çalışmaya katılanlardan 32 (%24,8) si hiçbir kişisel koruyucu donanım (KKD) kullanmıyordu. Radyasyona maruz kalındığı gün 91 kişi diğer günlerden farklı olarak halsizlik, yorgunluk, baş ağrısı gibi bir şikayet hissediyormuş. KKD kullanımının öğrenim düzeyi ve radyasyon eğitimi almakla ilişkisi olmadığı saptandı.

Sonuç: Radyasyona maruz kalan sağlık çalışanlarının çoğu radyasyon ile ilgili daha önce bir eğitim almamış ve KKD'leri düzenli kullanmamaktadır. Bu durum kişinin gün sonunda halsizlik, yorgunluk ya da baş ağrısı gibi şikayetleri olmasına neden olmaktadır.

Anahtar kelimeler: Radyasyon, iyonize radyasyon, sorgulama formu, X-ışını, bilgisayarlı tomografi

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INTRODUCTION

Radiological imaging has recently been used frequently in the diagnosis, treatment and follow-up of diseases [1]. Departments such as surgical branches, radiology, anesthesia, cardiology, neurology and operating theatre employees, are the main units exposed to radiation. The degree of exposure to ionizing radiation varies according to the radiological imaging applied and computed tomography, conventional radiography, C-arm fluoroscopy, angiography are the best-known ionizing radiation sources used in hospitals.

The most basic way to protect from ionizing radiation is to use the radiation as little as possible [2]. Surgeons, interventional radiologists, cardiology, and neurology departments that use fluoroscopy frequently in particular, will find that the less fluoroscopy they perform during the procedure, the less radiation they are exposed to. Another way to reduce radiation exposure is to stay away from the radiation source as much as possible during fluoroscopy or radiological imaging [3]. In order to reduce the effect of ionizing radiation, it is absolutely necessary to use personal protective equipment (PPE) and, if possible, to put a screen such as a glass partition between the radiation source and the operators [4].

Although the harmful effects of radiation are generally known, the degree of damage it causes in the chronic process is not fully understood. Health workers are exposed to the harmful effects of radiation at least as much as patients and when we consider chronic exposure, this damage can reach serious levels and lead to life-threatening diseases that can result in death [5]. In this study, we aimed to evaluate the awareness of the harmful effects of radiation in healthcare professionals exposed to ionizing radiation, at the Alanya Alaaddin Keykubat University Training and Research Hospital and the Süleyman Demirel University Hospital.

MATERIALS AND METHODS

Study Population

We conducted this study at the Alanya Alaaddin Keykubat University Training and Research Hospital and the Süleyman Demirel University Hospital, where physicians, nurses, paramedics, anesthesia technicians, caregivers as well as cleaning staff exposed to radiation, participated in the study. The units where the study participants worked in were urology, orthopedics, neurosurgery, radiology, interventional radiology, angiography, general surgery, otolaryngology, gynecology and obstetrics, plastic and reconstructive surgery, ophthalmology and the operating theatre. The total service time in the unit where they are exposed to radiation was stated in months, the daily exposure time in minutes and their distance to the radiation source in meters (m). X-ray, C-armscopy or fluoroscopy, computed tomography were sources of ionizing radiation to which they were exposed to.

Questionnaire

We prepared a questionnaire to carry out the study, in which we noted the demographic characteristics of the participants and the department they worked in. We asked how long they were exposed to radiation, how far they worked from the radiation source, the side effects they fear the most, how many days in a month and how much time they were exposed to radiation in a given day. In addition, they were asked whether they had radiation training, whether they were given time away from the radiation environment, whether they used a personal dosimeter (PD), whether they used PPE, which PPEs they used, whether they felt any symptoms such as weakness, fatigue, headaches different from other days on the day of radiation exposure, whether they had a disease due to radiation exposure. They were asked whether they used lead gowns, thyroid shields, gloves, glasses, glass partitions or screens as PPE. They were offered the following options as side effects of radiation that they may be aware of and feared the most: cancer, infertility, genetic disorder, shortening of life span, cataract, hair loss, skin disorders, growth retardation in children and other.

Analysis and Statistics

The personal and professional demographic characteristics of the participants were recorded and descriptive statistics were compiled with the data obtained. If the data showed normal

distribution, the results were given with mean ± standard deviation, otherwise median value + minimum-maximum values were given. Working periods in the department with radiation exposure were divided into 3 groups from 0-5 years, 5-10 years and more than 10 years. In terms of dosimetry use, the participants were divided into 3 groups: those who use it regularly, those who never use it and those who occasionally use it. The relationship between formal education levels and regular usage of PPE, the relationship between having radiation education and regular usage of PPE, and the relationship between the distance to the radiation source and the presence of radiation-related complaints on that day, were statistically analyzed. In comparison of qualitative data, Pearson's chi-square test was used for those whose expected value was less than 5 and the ratio of cells was less than 20%, and the Fisher exact test was used for those with an expected value greater than 20%. If the parametric test assumptions were not been provided, the Mann-Whitney U test was used to compare the quantitative data in the two groups. A threshold value of <0.05 for the level of significance was considered significant. Whether the data was normally distributed was determined by Shapiro-Wilk test and if the p value as a result was >0.05 , the data was considered to be normally distributed. Statistical measurements were made with the SPSS 22 package program (SPSS Inc., Chicago, IL).

Ethical considerations

All procedures in this study involving human participants were performed in accordance with the ethical standards of the Institutional Research Committee and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards. This study was approved by Alanya Alaaddin Keykubat University Medical Ethics Committee, (10354421 - 2019/13-47) Turkey

RESULTS

One hundred twenty-nine healthcare professionals, 81 men and 48 women, participated in the study. The mean age of the participants in the study was 36.8 ± 8.61, 95 were married and 34 were single. There were 21 doctors, 88 nurses or health officers or technicians, 20 caregivers or staffs in the study. In terms of working experience, there were 27 persons between 0-5 years, 21 persons between 5-10 years and 81 persons who had been working more than 10 years. When we looked at the education levels, 72 persons had associate and lower degrees, 57 had undergraduate and higher degrees. There were 31 persons using extra holiday time due to radiation, whereas 98 persons were not. Fifty-seven of the participants had previously had formal radiation training and 72 had not. When we looked at the use of PD badge, 29 persons used it regularly and 93 persons never used it, whereas 7 persons sometimes did. Among those using dosimeters, 4 persons were using one for 12 months or less, 9 persons for 13-60 months and 23 persons for more than 60 months (Table 1).

Table 1. Demographic characteristics of the study participants

Parameter	Number (n)	Percentage (%)
Male	81	62.8
Female	48	37.2
Married	95	73.64
Single	34	26.35
Doctor	21	16.27
Nurse or health officer or technician	88	68.21
Other health personal	20	15.5
Education background		
Undergraduate or higher	57	44.18
Associate or lower	72	55.81
Working year		
0-5 years	27	20.93
5-10 years	21	16.27
>10 years	81	62.79
Education for Radiation		
Yes	57	44.18
No	72	55.81
Radiation Rest		
Yes	31	24.03
No	98	75.97
Dosimeter usage		
Always	29	22.48
Never	93	72.09
Sometimes	7	5.42

It was found that, on a monthly basis, 60 persons were exposed to radiation for 10 days or less, 52 persons were exposed to radiation for 11-20 days and 17 persons for 21-30 days. During a given radiation exposure day, 48 persons were exposed to an average of 0-60 minutes,

41 persons averaged 61-180 minutes and 40 persons averaged more than 180 minutes. As a radiation source, 97 persons were exposed to C-arm scope, 26 to X-ray, 18 to tomography and 22 of them to more than one source. During the process, 36 persons were closer than 1 meter to the radiation source, 65 persons were 1-3 meters away, whereas 28 persons were more than 3 meters away (Table 2).

In the questionnaire, to the question "whether protective equipment (PE) is enough" 16 persons answered yes, 44 persons no, 69 persons answered that it was partially sufficient. To the question of "do you use PPE", 64 persons answered that they used it, 29 did not and 36 persons used it sometimes. Twenty-two persons who did not use PPE were closer than 3 meters to the radiation source. As PE, 95 persons used lead vests, 73 persons used thyroid shields, 6 persons goggles, 3 of them used gloves and 47 persons used lead screen. Thirty-two participants (24.8%) answered that they do not use any PE during the procedure (Table 2).

Of the participants in the study, 5 persons did not know that radiation can cause cancer, 17 persons understood it can cause infertility and 39 persons that it can cause genetic disorders. On average, half of the participants did not know that radiation can shorten the life span, cause cataracts, hair loss, skin disorders or lead to growth retardation in children. To the question "What is the side effect you fear the most from radiation?" 122 persons answered cancer, 11 answered infertility and 8 persons answered cancer and infertility. On the day of exposure to radiation, 91 persons (70.54%) complained of symptoms such as weakness, fatigue and headache, unlike other days. Sixteen of the participants (12.4%) in the study had a disease that they thought was caused by radiation. Five of them were thyroid cancer, 4 were chronic headache or cranial mass, 2 were preterm birth or recurrent abortion (Table 2).

When the relationship between education level and regular usage of PPE were evaluated, the rate of regular PPE use for those with an undergraduate or higher level was 54.4%, while it was 45.8% for those with an associate or lower education level. The difference was not statistically significant according to Pearson's chi-square test ($X2(1) = 0.931$, $p = 0,335$). When the relationship between radiation education and regular use of PPE was evaluated, the rate of usage of PPE in for those who had received radiation training was 56.1%, while it was 44.4% in those who did not have such training. The difference was not statistically significant according to the Pearson's chi-square test ($X2(1) = 1.741$, $p=0,187$). It was therefore determined that PPE usage is unrelated to education levels or radiation training.

Table 2. Results about radiation source, protective equipment and disease related radiation

Parameter	Number (n)	Percentage (%)
Radiation source		
C armscopy	97	75.19
Conventional X-ray	26	20.15
Computed tomography	18	13.95
Distance to radiation source < 1 mt	36	27.9
1-3 mt	65	50.38
> 3 mt	28	21.7
Protective equipment Lead vest	95	73.64
Thyroid shield	73	56.58
Screen	47	36.43
Goggles	6	4.65
Gloves	3	2.32
Most feared side effect Cancer	122	94.57
İnfertility	11	8.52
Genetic	5	3.87
Possibly radiation-related illness	16	12.4
Thyroid cancer	5	3.87
Headache	4	3.1
Gynecological problem (abortus, prematurity)	2	1.55

The median value of the distance to the radiation source was found to be 2 m (0.1-8 m), while the median distance to the radiation source was found 2 m (0.1-5 m) in those who experienced a different complaint due to radiation exposure, and the median distance to the radiation source was found 3 m (0.3-8 m) in those who did not feel any complaint due to radiation exposure. The relationship between the presence of complaints such as weakness, fatigue and headache that the person felt, different from the other days and resulting from radiation and the distance to the radiation source, was examined with the Mann-Whitney U test: the results were found to be significant (U: 1324, p: 0.035). The closer

the person works to the radiation source, the more likely they are to feel complaints such as weakness, fatigue and headache that day due to radiation exposure.

DISCUSSION

Healthcare professionals are generally aware of the long-term damage that radiation exposure may cause in the body. However, their knowledge of the actual harmful effects of radiation exposure is very poor. In a study conducted in the UK on physicians' estimation of the radiation emitted by X-rays, 97% of the physicians estimated it was lower than the actual dose [5]. In a study involving 1184 persons in which European urology assistants participated, the knowledge of the participants in the study about the damages of ionizing radiation was found to be weak, and it was concluded that on average, half of the participants had no idea that ionizing radiation causes fatal cancer [6]. In our study, it was found that only 5 persons did not know that it caused cancer and 17 did not know that it caused infertility. The least known side effect of radiation was found to be cataracts and growth retardation in children. The reason for these low rates may be the recent increase in cancer and infertility rates, as well as the fact that radiation exposure is known by the majority of people in society to cause these diseases.

PPE must absolutely be used to eliminate or minimize the harmful effects of radiation [7,8]. In a study conducted by Bowman et al., they found that 33.8% of 518 persons did not use lead protection equipment [9]. Only 54.2% of the participants had their own lead vest and thyroid shields, while 12% had a fully equipped protection system consisting of vest, thyroid shield and goggles, which was a comparable rate to the one found in our study. The reason for the thyroid shield being used less frequently than the lead vest may be the discomfort it causes on the neck. Other PPE usage rates were found to be quite low in our study; the reason for the low usage of goggles and gloves, for instance, may be that the institution does not provide this equipment, that they have a high cost as well as the inconvenience they may cause during their usage.

Raising the awareness of healthcare professionals about the harmful effects of radiation and providing training on this subject, reduces exposure to radiation and increases the usage of PPE, resulting in less exposure to harmful effects [10]. In addition, formal training on radiation provides more accurate usage of radiation sources and similarly, provides less exposure to radiation [11]. In our study, only a small portion of the participants received radiation training. We observed that there was no relationship between the person's undergraduate education level and the rate of using PPE. In order to increase the use of PPE in healthcare professionals exposed to radiation, training should be given at regular intervals during the course of their professional life. Training about radiation should be focused on how to minimize exposure, which PPEs should be used and how much protection these PPEs actually provide, as well as the importance of PD in general.

It is necessary to use a PD badge to clearly understand the cumulative amount of radiation the person is exposed to. Dosimeter badges for instance, are controlled periodically to measure the amount of radiation exposure, though if there is more radiation exposure than expected in these, it may be because of their misuse, insufficient PPEs or exposure of the person to unusually intense radiation [12]. In our study, the usage of PD badges was found to be very low and in the literature, in one particular study, when asked "why don't you use PD badges", most of the participants answered that "I work in many different places and I cannot remember the dosimeter badge" [13]. In Turkey, dosimeter badges are usually provided by the institution and the reason for the low usage in our study may be that the specific institutions did not provide these or, as in the literature, participants simply forgot to wear them.

Although every organ can be affected in chronic radiation exposure, the hematopoietic system is particularly affected [14]. In our study most of participants had been working for more than 10 years and closer than 3 meters to the radiation source, and most of them did not use PPE regularly. Malignancy, infertility, skin lesions, retinopathy, cardiovascular diseases, chronic fatigue syndrome, thyroid diseases, fetal malformation and growth retardation, are the best known pathologies caused by ionizing radiation [15-19]. In our study, the rate of those who thought they

had radiation-related disease was 12.4%. Thyroid cancer was found to be the most common disease resulting from radiation exposure, whereas the prevalence of thyroid cancer in the community is very low [20]. In our study, the reason for the higher rate of thyroid cancer compared to the general population is most likely radiation exposure. In addition, participants, to a considerable extent, reported that on the days they were exposed to radiation, they experienced different symptoms from other days, such as weakness, fatigue and headaches. Park et al. demonstrated the effects of radiation on the brain's hippocampus in an animal study [21] and therefore, it is reasonable to think that these complaints may occur in the person as a result to damage caused by the radiation in that region of the brain.

Our study has some limitations, one of which was that the exact radiation dose exposed by the healthcare professionals could not be calculated. If the usage of PD badges were sufficient and the data obtained from them could have been examined, a more obvious relationship could have been established with the diseases. Another deficiency was that not all healthcare professionals exposed to radiation in the two institutions were included in the study. If this would have been possible, clearer information about these would have been obtained and it would be possible to correct errors regarding radiation exposure.

Conclusion: The number of departments and healthcare professionals exposed to radiation in the hospitals was quite high. Also, the knowledge required on the part of the healthcare professionals about radiation, in order to minimize exposure, was insufficient. In our study, it was found that healthcare workers exposed to ionizing radiation have low radiation exposure awareness. For this reason, it was concluded that the level of knowledge of healthcare professionals about radiation, the side effects that may occur as a result of exposure, as well as the importance of PPE usage, should all be increased.

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