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Knowledge About Ionizing Radiation and Radiation Protection Among Patients Awaiting Radiological Examinations: A cross-sectional survey

Radyolojik Tetkik Bekleyen Hastaların İyonizan Radyasyon ve Radyasyondan Korunma Konusunda Bilgi Düzeyleri: Kesitsel Bir Anket Çalışması

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ABSTRACT: ***Purpose:*** To evaluate the level of knowledge about ionizing radiation and radiation protection among patients who underwent radiological examinations.
Materıals and Methods: A cross-sectional survey was carried out of 224 patients in the university hospital. A questionnaire which tested patients' information about ionizing radiation, harmful effects and protection from these effects was applied by medical school students. The score for 24 knowledge questions was evaluated out of a total of 100 points.
Results: Of the participants, 32.6% had completed primary school. The majority of patients (91.5%) had had previous radiological examinations. The mean score was 54.78±20.08. There was no significant difference between female (55.72±19.44) and male (53.54±20.93), and between low (54.30±18.45) and high (55.27±21.71) educated participants (P>0.05). The patients who had CT examination previously had significantly higher points (59.76±18.23) than the patients who had not (51.38±20.66) (P=0.002). The score was significantly different (P=0.001) between the patients who realized that radiation could cause cancer (57.78±19.87) and who could not (46.56±18.42). The ratio of knowing this question increased with the education level (P=0.032).
Conclusion: Although many of the participants had radiological examinations previously, they had insufficient knowledge about radiation protection. Since the level of education for most patients was primary school, it would be appropriate to include lessons about radiation and side effects in primary schools In waiting rooms, informative brochures about radiation protection could be useful for the patients.
Key Words: Radiation protection; radiological health; radiation effects.

ÖZET: ***Amaç:*** Radyolojik tetkik için gelen hastaların iyonizan radyasyon ve radyasyondan korunma hakkında bilgi düzeylerini araştırmaktır.
Gereç ve Yöntem: Üniversite hastanesinde 224 hastaya kesitsel bir anket uygulandı. Tıp fakültesi öğrencileri tarafından hastalara iyonizan radyasyon, zararlı etkileri ve bu etkilerden korunma hakkında sorular soruldu. Puanlar, 24 bilgi sorusu için toplam 100 üzerinden değerlendirildi.
Bulgular: Katılımcıların %32.6 ilkokul mezunuydu. Hastaların çoğu (%91.5) daha önceden radyolojik tetkik yaptırmıştı. Ortalama puan 54.78±20.08 idi. Puanlar açısından kadınlar (55.72±19.44) ve erkekler (53.54±20.93) arasında, ve düşük (54.30±18.45) ve yüksek (55.27±21.71) eğitim düzeyli katılımcılar arasında anlamlı fark saptanmadı (P>0.05). Daha önce BT tetkiki yaptıranlarda puanlar (59.76±18.23), yaptırmayanlardan (51.38±20.66) anlamlı şekilde yüksekti (P=0.002). Radyasyonun kansere neden olduğunu bilenlerin puanı (57.78±19.87) ile bilmeyenlerin (46.56±18.42) arasında anlamlı fark vardı (P=0.001). Bu soruyu bilme oranı eğitim düzeyi ile artma gösteriyordu (P=0.032).
Sonuç: Katılımcıların çoğu daha önceden radyolojik tetkik yaptırmış olmalarına rağmen, radyasyondan korunma hakkında yetersiz bilgiye sahipti. Hastaların çoğu ilkokul mezunu olduğundan, ilkokulda radyasyon ve korunma hakkında dersler konulmalıdır. Fakat en önemli rol radyoloji bölümlerine düşmektedir, radyasyondan korunma hakkında bilgilendirme broşürleri hastalar için yararlı olacaktır.
Anahtar Kelimeler: Radyasyondan korunma, radyolojik sağlık, radyasyonun etkileri

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INTRODUCTION

Radiological examinations are an essential tool for the evaluation of many disorders in daily practice. Most of them, especially computed tomography (CT), use ionizing radiation which has adverse biological effects. Doses of whatever magnitude are assumed by International Commission on Radiological Protection (ICRP) to be able to induce what are referred to as "stochastic effects" (i.e. cancers and hereditary disorders) (1). Dose-dependent effects are called as "deterministic effects" that may be responsible for teratogenicity in diagnostic radiology (1,2). These effects are also useful for cancer therapy. Radiation therapy uses high-energy radiation to shrink tumors and kill cancer cells. Radiation therapy is sometimes given with curative intent (that is, with the hope that the treatment will cure a cancer, either by eliminating a tumor, preventing cancer recurrence, or both) (3).

Many studies showed that knowledge about ionizing radiation was insufficient among medical students and physicians who requested radiological procedures, even radiologists who should have had more information than non-radiologists (4-12). There are only two studies about patients' awareness of ionizing radiation effects on the human body in the literature (7,13). To the best of our knowledge, this is the first study which evaluated the patients' knowledge level.

The aim of the study was that not only to determine knowledge about ionizing radiation and radiation protection among patients awaiting radiological examination, but also to take their attention to importance of ionizing radiation in their life.

MATERIALS AND METHODS

A cross-sectional survey performed between 15 and 22 February 2008 among patients who referred for the radiological examinations to the radiology department of the university hospital. The study included 224 patients (127 [56.7%] female and 97 [43.3%] male; mean age, 41.70±14.05 years; age range, 18-77 years) who accepted to be participant. A questionnaire which tested patients' information about ionizing radiation, harmful effects and protection from these effects was applied by medical school students before radiological examination. The questionnaire which was face to face surveyed by the medical school students evaluated the following informations: demographic data (age, gender, marital status, employment, education level [low education level: illiterate, primary and secondary school educated; high education level: high school and university educated]), what radiation and x-ray are, what harmful effects of ionizing radiation are, which radiological examinations use ionizing radiation, which radiological examinations could be used safely for pregnant women, what they should do for protection from radiation were investigated. Participants were not allowed use any materials or sources during the test. The questionnaire was a combination of multiple-choice and yes-no (true-false-no idea) questions, and 24 of these were aimed at knowledge evaluation. They were given 4.2 points for each correct answers, and the score per participant was evaluated out of a total of 100 points. Informed consent was obtained from all participants.

Statistical analysis

Statistical analysis was done using a SPSS version 13.0 statistical programme. Data were analyzed statistically by the t-test and Chi-square test. All parametric results were expressed as mean ± SD for each group. Local statistical significance was assumed as $p<0.05$ for all parameters.

RESULTS

Sociodemographic characteristics of participants are shown in Table 1. The highest frequency of education level belonged to primary school educated participants (32.6%). Unemployed patients' (42.9%) frequency was the highest one among the employment category. Distribution of the correct answers of the survey are summarized in Table 2.

Most of patients (91.5%) underwent radiological examinations previously and 46.9% of them knew the radiation mean. While 68.3% of patients knew that radiography use x-ray, only 33% of them knew that mammography use x-ray. The participants believed that radiography 72.8% and CT 71.4% were harmless during pregnancy. But 33.5% (21.9 % had no idea) of them also believed MRI use x-ray and 66.5% (19.6% had no idea) avoided this examination during pregnancy. While 20.5% of them knew that CT contained more x-ray than radiography, 73.2% had no idea about this issue. Many of patients knew that x-ray could cause cancer (73.2%) and fetal anomaly (69.2%). Interestingly, 22.3% of patients declared that thick cloths could protect them from harmful effects of x-ray.

When scoring was done for each correct answer, the mean score was 54.8±20.1 (ranging between 12.5 and 99.8) out of 100. Comparison of several groups' responses according to scores are evaluated in Table 3. There was no statistically significant difference in the scores between female (55.72±19.44) and male (53.54±20.93), and between low (54.30±18.45) and high (55.27±21.71) education level of participants (P>0.05). The score of the patients who underwent CT examinations previously (59.76±18.23) was significantly higher than the patients who did not (51.38±20.66) (P=0.002).

The score was significantly different (P=0.001) between the patients who realized that radiation could cause cancer (57.78±19.87) and who did not (46.56±18.42). The ratio of knowing this question significantly increased with the education level (P=0.032). According to education level, comparison of the patients who knew that radiation could cause cancer and who did not was shown in Table 4.

Table 1. *Sociodemographic characteristics of participants.*

Characteristics	**n=224**	**%**
Gender		
Male	97	43.3
Female	127	56.7
Educational status		
Illiterate	18	8.0
Primary school	73	32.6
Secondary school	24	10.7
High school	50	22.3
University	59	26.3
Employment		
Unemployed	96	42.9
Retired	39	17.4
Official	30	13.4
Worker	20	8.9
Self-employed	20	8.9
Others	19	8.5

Table 2. *Distribution of the correct answers of the survey*

Questions	**n=224**	**%**
Radiation is the reliase and transfer of energy.	105	46.9
X-ray is the form of ionizing radiation using in radiology.	120	53.6
Approximately 82% of radiation which we are exposed every year comes from natural sources.	85	37.9
Which of the following could be seen as an adverse effects of ionizing radiation? (you can mark more than one)		
Cancer	164	73.2
Fetal anomaly	155	69.2
Cataract	75	33.5
Cell death	133	59.4
Skin lesions	132	58.9
The x-ray dose in radiotherapy for cancer patients is almost 500.000 times more than radiological examinations.	51	22.8
Of the following, which modality use ionizing radiation? (you can mark more than one)		
Ultrasonography	132	58.9
Radiograhy	153	68.3
CT	104	46.4
MRI	100	44.6
Mammography	74	33

Questions	n=224	%
Which of the following could be used safely for pregnant women? (you can mark more than one)		
Ultrasonography	148	66.1
Radiograhy	160	71.4
CT	163	72.8
MRI	31	13.8
Mammography	159	71
Total ionizing radiation dose in one abdominal CT scan almost equvalents 500 chest radiographs doses.	46	20.5
Which of the following shoul do for protection from harmful effects of x-ray? (you can mark more than one)		
Cover the sensitive areas with Pb plaquesi	117	52.2
Doing the examination contain lesser x-ray	158	70.5
Wearing thicker clothes	174	77.7
Do not stay in the examination room unnecessarily	194	86.6

Table 3. *Comparison of each group's responses according to scores.*

(First group) vs (Second group)	First group score (mean±SD)	Second group score (mean±SD)	P* value
(Male) vs (female)	53.54±20.93	55.72±19.44	0.423
(Illiterate, primary-secondary) vs (higher)	54.30±18.45	55.27±21.71	0.719
(Underwent radiological examination previously) vs (did not)	54.99±20.19	52.49±19.18	0.604
(Underwent CT examination previously) vs (did not)	**59.76±18.23**	**51.38±20.66**	**0.002**
(Knew radiation means) vs (did not)	58.40±20.66	59.19±19.00	0.900
(Knew radiation could cause cancer) vs (did not)	**57.78±19.87**	**46.56±18.42**	**0.001**

*Compared by using the t-test.

Table 4. *According to education level, comparison of the patients who knew that radiation could cause cancer and who could not.*

Educational status	Radiation		P* value
	Could cause cancer n (%)	Could cause cancer n (%)	
Illiterate	9 (50.0)	9 (50.0)	**0.032**
Primary school	49 (67.1)	24 (32.9)	
Secondary school	18 (75)	6 (25.0)	
High school	38 (76)	12 (24.0)	
University	50 (84.7)	9 (15.3)	
Total	164 (73.7)	60 (26.8)	

*Compared by using the Chi-square test.

Table 5. *Comparison of the incorrect answers of the previous studies which asked if MRI/US use ionizing radiation.*

Study Authors (year)	US %	MRI %
Shiralkar et al. (2003)	5	8
Jacob et al. (2004)	10	28
Thomas et al. (2006)	4	-
Arslanoglu et al. (2007)	4	27.4

DISCUSSION

More than 50% patients realized that US do not use ionizing radiation, but less than 50% knew that MRI also do not. Several studies showed that many physicians do not have this knowledge (5,6,8,9). The incorrect answers of the studies which asked if MRI or US use ionizing radiation were shown in Table 5. Jacob et al. found the most dramatic results that almost 1 out of 10 doctors did not know that US does not use ionising radiation, that 3 out of 10 doctors did not know that MRI does not use ionising radiation (6). From our country, Arslanoğlu et al found similar results, they were 4% and 27.4%, respectively (9). When the physicians' knowledge about US and MRI was compared with the patients' in our study who were mostly primary school educated, the frequencies of our study were very high and encouraging

Of the participants, 67% did not know mammography use ionizing radiation. The potential radiation hazards associated with routine screening mammography, in terms of breast cancer induction, are discussed in the literature (14). This important point should be known by the patient. They can protect themselves as avoiding mammography examination younger than 35 years and keeping older mammograms for preventing unnecessary repetition of the examination in a very short period.

Several studies reported that physicians were unable to accurately estimate the dose for one CT scan compared with that for one chest radiograph (4-8). Lee et al also reported that only 5% radiologists accurately estimated the dose (7). While Quinn et al. (4) reported that almost 65% of physicians underestimated the dose of abdominal CT, Thomas et al. (8) reported the same ratio as 97%. Interestingly, similar result were found in the study which designed for patients. The question of "if total ionizing radiation dose in one abdominal CT scan almost equivalents 500 chest radiographs doses" was answered correctly by 20.5% of patients. In Lee et al's study, none of patients estimated accurately the dose (7). It seems that patients in the study had almost same level of knowledge about the CT dose compared with that for one chest radiograph with the physicians. But the question was a true-false question in the survey, but it was multiple choice format in the other studies (4-9). This difference of the format could effect the result which was better in our study. And it should be reminded that 73.2% of participants had no idea about this issue.

It was reported that an estimated 100-250 deaths occur each year from cancers directly related to medical exposure to radiation in United Kingdom (4,5). In United States, the approximate number of deaths attributable to CT was 700-1800 during a year (15). Most of the responders (73.2%) perceived that cancer could be seen as an adverse effects of ionizing radiation. Lee et al reported that only 3% of patients believed possible lifetime cancer risk associated with a diagnostic CT scan. In the same study, the ratios of the same issue belonged to the emergency department physicians and the radiologists were 9% and 47%, respectively (7). Our result suggests that patients' awareness about cancer risk associated ionizing radiation was very high. It could be explained by media factor, as radio and TV, on the mostly low educated patients. The Chernobyl nuclear central accident has affected the north cost of the our country, and increasing cancer patients and victims with fetal anomaly at that area were announced by media several years. With highly frequency (69.2%), the participants also knew that fetal anomaly could be seen as an adverse effects of ionizing radiation.

Most of the participants believed that it should be avoided from MRI examination during pregnancy. As it was discussed above, many of patients also believed MRI use ionizing radiation or had no idea. This misperception could lead to increased unnecessary anxiety level when they or relatives should undergo MRI examination while they are pregnant.

One of the important findings of the study was that the score of the patients who realized that radiation could cause cancer was significantly higher than the patients who did not. Furthermore, the ratio of knowing this question significantly increased with the education level. Because the highest frequency of education level belonged to primary school educated participants, information about radiation should be started in primary school. Unemployed patients' frequency was the highest one among the employment category. If we think that they spend most of their times at home with TV, programs about radiation and its effects could be useful for taking their attention.

Other important findings of the study was that the score of the patients who underwent CT examinations previously was significantly higher than the patients who did not. It could be explained that patients spend much time during CT process, especially abdominal CT scan and it could be a

chance to communicate with radiology stuff and to learn something.

Recent high-speed multidetector row CT technology creates more defined images and new applications but at the same time, physicians' CT requests are almost 20% increased unnecessarily (7,16). Furthermore, as many as 30% of all pediatric CT examinations could be easily and effectively replaced by a nonionizing imaging techniques (17). Larson et al determined that how parents' understanding of and willingness to allow their children to undergo CT change after receiving information regarding radiation dose and risk. They concluded that a brief informational handout can improve parenteral understanding of the potential increased risk of cancer related to pediatric CT without causing parents to refuse studies recommended by the referring physician (18). But such information about radiation could reduce the number of CT scans depends on many factors, including how often parents request CT for their children or themselves, how strongly patients influence ordering clinicians and how often such influence leads to inappropriate CT scan (18). In practice, patients believe that good doctor orders much examinations, including radiologic ones and prescripts much medicines. ALARA (as low as reasonably achievable) principles have been the standard in the radiology community for many years and are especially applicable in the case of pediatric CT (19). The principle is very easy to understand and should be always kept in mind among physicians and also patients. Patients could protect themselves from unnecessary radiological examinations.

In the literature, only one survey that was performed only patients has been reported by Fartum et al. (13). They mentioned that the patients were more aware of possible effects of radiation from high-voltage cables than of the effects from X-raying. Only three patients had been informed by their referring doctors that X-ray examination could have unwanted effects. They suggested that information to patients about diagnostic radiation should be improved (13). Lee et al also suggested that two possible methods include the posting of clear announcements with associated CT radiation doses and reference ranges in CT department waiting areas and the availability of informational pamphlets in outpatient waiting rooms. National radiology associations are probably best suited for assuming the leaderships for production of such educational material without causing public fear (7,20).

In conclusion, education is the most important factor for preventing unnecessary radiological examinations not only among physicians but also among patients. Improving of awareness of the patients about ionizing radiation and harmful effects should protect them from increasing lifetime cancer risk. In the education, government has responsibility to start giving information about radiation from primary school, national radiology community has responsibility to publish and deliver informative brochures, radiologists have responsibility to organize meetings, conferences, even TV programs.

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