Diagn Interv Radiol 2007; 13:53-55

GENERAL RADIOLOGY

ORIGINAL ARTICLE

Doctors' and intern doctors' knowledge about patients' ionizing radiation exposure doses during common radiological examinations

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PURPOSE
To investigate the level of doctors' and intern doctors' knowledge about patients' radiation exposure doses during common radiological examinations.

MATERIALS AND METHODS
A questionnaire listing the radiation doses of routine radiological diagnostic procedures was administered to 177 doctors and intern doctors. We asked them to find the equivalent doses of radiation for common radiological examinations when a normal chest X-ray is accepted as one unit. Data were analyzed with k-square and Fisher's exact k-square tests.

RESULTS
In all, 93.1% (n = 156) of the doctors and intern doctors underestimated the actual radiation dose, 4% (n = 7) did not know that ultrasound does not utilize ionizing radiation, and 27.4% (n = 47) did not know that magnetic resonance imaging does not entail ionizing radiation.

CONCLUSION
Most of the doctors and intern doctors underestimated real radiation doses. This lack of awareness may cause doctors to order more radiological investigations than they would if properly educated. Therefore, we propose mandatory education about radiation protection in the medical school.

Key words: • *ionizing radiation* • *medical education* • *radiological examinations*

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Received 19 April 2006; revision requested 26 March 2007; revision received 4 April 2007; accepted 13 April 2007.

Radiation has been proven to have adverse biological effects on living organisms. These adverse effects vary according to dose and duration of exposure (1, 2); however, the threshold dose for causing cancer in humans is as yet unknown. Some experimental and epidemiological investigations have tried to determine this threshold (1). Radiation is used widely in the diagnosis and treatment of many diseases, but limited usage of radiation for medical purposes is important. Previous investigations proved that doctor knowledge of radiation safety is insufficient and hundreds of unnecessary examinations are performed every year (3–5). In our study, the level of doctor and intern doctor knowledge about radiation doses received by patients during some common radiological imaging procedures was investigated.

Materials and methods

The study included doctors and intern doctors from 3 university hospitals, and doctors from an education and research hospital, one dispensary, and 3 outpatient clinics. Our study was a descriptive investigation performed between February and May 2005. The questionnaire that was administered to the study participants was composed of demographic questions concerning age, gender, institution, year of medical school graduation, current status of duty, and department or specialty, as well as questions about doses of ionizing radiation that patients receive during radiological imaging examinations listed in Table 1 proportional to a chest X-ray. The answers were evaluated according to the UNSCEAR 2000 report (6) and were considered correct within 20% deviation. The UNSCEAR 2000 report lists in detail the ionizing radiation doses of radiological examinations according to country. The mean values of different countries are shown in the last rows of the tables. As the equivalent doses for the examinations included in the questionnaire were not available for Turkey, mean of all countries was accepted (6). Data were analyzed with the SPSS 10.0 software program (SPSS Inc., Chicago, Illinois, USA). Statistical analyses were evaluated with k-square and Fisher's exact k-square tests. $P < 0.05$ was accepted as statistically significant.

Results

Mean age of the participants was 31.58 ± 6.60 years. Distribution of the participants according to descriptive features is listed in Table 2. In all, 93.1% (n = 156) of the doctors and intern doctors underestimated the actual ionizing radiation dose received by patients during radiological imaging procedures (Table 3), and 4% (n = 7) and 27.4% (n = 47) of the participants, respectively, claimed that abdominal ultrasonography (US) and abdominal magnetic resonance imaging (MRI), which do not use ionizing radiation, exposed patients to ionizing radiation (Table 4). More female doctors (39%) thought abdominal MRI exposed pa-

tients to ionizing radiation than male doctors (19%) ($P < 0.05$). The question about the dose of abdominal MRI radiation was answered incorrectly by more general practitioners (42%) and doctors that graduated >10 ago than the other participants ($P < 0.05$).

Discussion

Radiological examinations have an indispensable role in the diagnosis and treatment of disease, although radiation has been proven to have adverse biological effects on living organisms. These adverse effects vary according to the dose of radiation and duration of exposure (1, 7–9). Annually, 100–150 people die as a result of cancer secondary to medical radiation exposure (3–5).

Results of our study showed that 93.1% (n = 156) of doctors and intern doctors underestimated the actual ionizing radiation dose patients are exposed to during diagnostic procedures. Underestimation of the actual dose of ionizing radiation might lead doctors to request radiological examinations more often than is necessary and safe. This means increased risk for patients. In some countries radiological safety courses are offered to doctors in order to decrease the number of unnecessary examinations, but it was also demonstrated that these educational courses were not enough (3–5, 10). Pre-evaluation of all the requests for radiology procedures is not a practical solution for overburdened radiology departments. Patient databases and radiological data system software have shown great improvement in recent years. Radiation doses received by patients and their equivalent to chest X-rays might be shown by these programs and doctors might then review the implications and cancel examinations that can only minimally assist diagnosis.

We found that 4% (n = 7) and 27.4% (n = 47) of the participants, respectively, thought that abdominal US and abdominal MRI, both of which do not use ionizing radiation, exposed patients to such radiation. Doctor and intern doctor awareness of examinations that do not expose patients to ionizing radiation might result in their preference for them when deciding what procedures to recommend. For example, US is a practical and inexpensive method, but our study demonstrated that 4 of every 100 doctors thought US used ionizing radiation and 27 study participants thought MRI used ionizing radiation. Doctors might not prefer these techniques because of the misinformation they possess. More female doctors (39%) thought abdominal MRI exposed patients to ionizing radiation than male doctors (19%) ($P < 0.05$). The gender of doctors was statistically significant in our study, but we could not find similar data in the literature, and therefore the gender issue requires further study. The question about the radiation dose of abdominal MRI was

Table 1. Equivalent doses of radiation for radiological imaging examinations compared to chest X-ray (mSv)

Imaging technique	Dose (mSv)	Equivalent to chest X-ray
Chest X-ray	0.14	1
Abdominal CT	13.3	95
Lower extremity arteriography	12.4	88
Barium meal	3.7	26
Abdominal radiograph	0.55	3.92
Abdominal MRI	0	0
Abdominal US	0	0

mSv: millisievert, CT: computed tomography, US: ultrasonography, MRI: magnetic resonance imaging

Table 2. Distribution of study participants according to descriptive features

	n	Percentage
Gender		
Male	102	57.6
Female	75	42.4
Institution		
First step health center	34	19.2
Second and third step health center	143	80.8
Years of service		
Undergraduate (intern doctor)	14	7.9
<10 years	113	63.8
>10 years	50	28.2
Specialty		
Intern doctor	14	7.9
General practitioner	26	14.6
Pediatrician	24	13.6
Resident of pediatrics	30	17.0
Surgeon	18	10.2
Resident of surgery	31	17.5
Internal medicine	14	7.9
Resident of internal medicine	20	11.3
Total	177	100.0

answered incorrectly by more general practitioners (42%) and doctors that graduated >10 years previously (49%) than the other study participants ($P < 0.05$). This might have been due to the relatively low number of radiological examinations ordered by general practitioners. Additionally, as MRI is a relatively new technique, doctors that graduated >10 years ago might have less knowledge about its technique. Shiralkar et al. demonstrated that 97% of doctors underestimate the actual ionizing radiation dose received by the patient, and 5% claimed US and 8% claimed MRI used ionizing radiation (3). It was a surprising result that US and MRI were thought to use ionizing radiation, although they do not, and this basic knowledge must be emphasized during medical training. Jacob et al. reported that only 15%–29% of doctors estimated the actual equivalent dose of radiological examinations in comparison to chest X-rays, and that 10% thought US and 28% thought MRI used ionizing radiation (5). In a study by Quinn et al., most of the participants were reported to have greatly underestimated the actual dose of ionizing radiation received by patients, and these investigators found no statistically significant difference between the doctors who attended radiation safety courses and those that did not (4).

To the best of our knowledge, this is the first study in Turkey to examine doctor and intern doctor knowledge about radiation exposure, and our findings are similar to other studies in the literature. Radiation dose received during radiological examinations and their equivalents to standard chest X-ray (0.02 mSv), in mSv units, were questioned in other studies; however, in our questionnaire (in order to facilitate responses) we asked about the ionizing dose of common radiological examinations in comparison to chest X-ray.

This study demonstrated that the level of knowledge of the participants was inadequate and 93.1% of the participants underestimated the actual dose. In one study, 10–50 mSv of acute radiation exposure and 50–100 mSv of recurrent exposure were reported to induce cancer (1). Therefore, in radiological practice, in keeping with ALARA (as low as possible) principle, minimum exposure of the patient and radiology staff is mandatory. Radiological examinations that are unnecessary and not supportive of diagnosis create risk for patients. For this reason, mandatory radiation safety courses in medical schools, measurement of the effectiveness of postgraduate radiation safety education, performing research with larger series, and investigating the amount and causes of unnecessary radiological imaging techniques ordered by doctors might prove beneficial in reducing patient exposure to potentially harmful ionizing radiation.

Table 3. Distribution of answers to questions about radiation exposure dose of radiological imaging examinations that use ionizing radiation

Imaging technique	Less than actual dose		Equal to actual dose		More than actual dose	
	n	%	n	%	n	%
Abdominal CT (n = 171)	143	83.6	14	8.2	14	8.2
Lower extremity arteriography (n = 170)	157	92.3	4	2.4	9	5.3
Barium meal (upper gastrointestinal series) (n = 171)	160	93.6	3	1.7	8	4.7
Abdominal radiography (n = 173)	165	95.3	0	0	8	4.7

CT: computed tomography

Table 4. Distribution of answers to questions about radiation exposure dose of radiological imaging examinations that do not use ionizing radiation

	Exposure to ionizing radiation			
	Present		Absent	
Imaging technique	n	%	n	%
Abdominal US (n = 172)	7	4.0	165	96.0
Abdominal MRI (n = 171)	47	27.4	124	72.6

US: ultrasonography, MRI: magnetic resonance imaging

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