Introduction

Interventional radiology/cardiology procedures as therapeutic/educational materials are accompanied with exposing many radiation risks for cardiology and radiology residents/fellows.1–3 Cataracts and skin injuries including erythema and hair loss have been reported in staff exposed to excess amount of radiation for teaching cardiology residents and fellows.1 And even in some studies, cancer has been reported as one of the most important outcomes of prolonged radiation exposure in healthcare professionals.1–4 In one usual diagnostic angiography of the coronary arteries, a typical patient receives 1–10 millisieverts (mSv) radiation. This amount of radiation equals with sum of radiations that a healthy person might receive on an average of 2–3 years. Permissive radiation amount for cardiology and radiology resident/fellows is 250 mSv each year and 2500 mSv for their lifetime. 1 mSv is the equivalent of approximately 10 chest X-rays.1

Based on radiation safety and protection protocols, using safety devices and annual assessment of radiation doses received by medical staff have been known among the best methods for decreasing radiation risks among healthcare professionals.5–6 In Iran, although interventional cardiologic therapeutic methods are applied extensively in many academic centres, there has not been any national and accurate report regarding assessment of radiation exposure level among cardiology and radiology resident/fellows within their educational years. Moreover, there is no clear evidence for training radiation safety protocols and using protective devices among Iranian cardiology and radiology residents/fellows in their training courses. A similar state exists in other countries as well and limited reports are in the literature about this topic.7

There are some unanswered questions about current awareness/practice of cardiology and radiology residents/fellows about radiation protection. There include the educational courses offered by the universities for residents about radiation exposure and its risks, the current state of safety devices usage, awareness about hazardous radiation risks, being familiar with international guidelines in this regard and so on. The present survey was designed for assessment of awareness and practice of Iranian cardiology and radiology residents/fellows about radiation safety protocols ad using protective devices.

Materials and Methods

Survey design

The present cross-sectional survey was performed between November 2011 and December 2012 among Iranian cardiology and radiology residents/fellows. All cardiology residents, cardiology (interventional, electrophysiology, paediatric, heart failure) fellows, radiology residents and interventional radiology fellows who were in training during the study period were eligible to enter to the study. The eligible study population was determined by contacting with all medical universities. All universities follow a common curriculum implemented by the Iranian Ministry of Health and Medical Education. About cardiology residents, those who were within the first year of their education were excluded from the survey and only those who have started attending catheterisation services were entered. This is because first-year cardiology residents rotate at internal medicine departments and have not started cardiology yet. It is to be noted that cardiology residency is not a subspecialty in Iran and residents start cardiology after medical school graduation and completion of 1-year internal medicine residency.

ABSTRACT

Objective To determine the current state of radiation safety awareness and practice among Iranian radiology/cardiology residents.

Methods In this cross-sectional study, 725 Iranian cardiology/radiology fellows/residents (685 residents and 40 fellows) were studied. Radiation safety awareness and practice were assessed using a 13-item survey questionnaire. Based on academic trainings provided in their medical centres, the subjects were divided into two groups (trained vs untrained).

Results Trained residents/fellows had better performance compared with untrained ones regarding awareness of radiation dealing instructions, knowing safety experts of their centres (43.8% vs 20.1%, p<0.001) and their contact information (38.4% vs 11.4%, p<0.001), date of the last CBC (complete blood count) checking (15.1% vs 2.5%, p<0.001), use of lead glass (61.6% vs 41.8%, p=0.003), apron (94.5% vs 90%, p=0.016) and radiation shield (71.2% vs 46.2%, p<0.001).

Conclusions Awareness/practice of Iranian cardiology/radiology residents/fellows about radiation exposure safety issues is not acceptable currently. Those who received formal training courses at their academic centres about the safety measures had significantly better knowledge compared with those who did not. It is suggested that radiation safety training be offered at the beginning of residency/fellowship for residents/fellows in a comprehensive and uniform way throughout medical universities.

Original research

Academic training in radiation safety awareness and practice among Iranian residents/fellows

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Survey questionnaire
The questionnaire was designed by the authors via group discussion with faculty members of our department, review of pertinent literature and review of the last guidelines of the International Commission on Radiological Protection (ICRP) and the Atomic Energy Organization of Iran (AEOI). It consisted of 13 questions in three main parts. Some questions assessed awareness of the respondents regarding radiation exposure and its risks. Some questions assessed protective devices/actions against radiation exposure among the participants and conformity of these actions with suggested international protection guidelines. Some questions were designed to assess the role of didactic activities on radiation protection awareness and the last part of the questionnaire comprised questions about assessment of practice of the participants in terms of safety radiation protocols and instruments. Also, application of radiation protection devices such as lead apron, glasses and shields was asked. The subjects were asked also to report not using safety devices, if applicable. Researchers compared knowledge and practice of study participants who passed training courses of protection from radiation expose with other participants. We used test–retest method to determine the reliability of the questionnaire by asking 75 residents/fellows to complete the questionnaire with a 10-day interval. Test–retest correlation was 0.78.

Survey participants
Totally 900 questionnaires were prepared to address all eligible residents via census sampling method. This figure was obtained from Iranian Ministry of Health and Medical Education that supervises all medical educational centres throughout the country. Sixty educational medical centres affiliated to 17 medical universities throughout the country constituted the study population. In most centres, the researcher participated and after oral explanation of the objectives of the study, the residents/fellows were asked to complete the questionnaires. In a limited number of centres where it was not possible to attend personally (due to far distance), the chief resident or faculty member responsible for educational affairs was contacted and was kindly asked to cooperate in the study and to complete the questionnaires. After completing them, the questionnaires were mailed to us.

Of 900 invited participants, 725 (response rate 80.56%) cardiology and radiology residents/fellows completed the questionnaires.

Statistical analysis
The data were collected and entered into the SPSS software for Windows (V20.0) for analysis. The descriptive indices frequency and percentage were used to report the data. The χ² test was used to compare qualitative variables. p Values <0.001 were set as statistically significant. These comparisons were done between two groups of the subjects (those who received formal training about radiation safety at the time of their training and those who did not have such experience). Formal training about radiation safety was defined as lecture held by universities according to guidelines of the ICRP or the AEOI with supervision by AEOI members and providing a syllabus to residents. Participation at this lecture is voluntary. The syllabus is prepared by the university, AEOI and Iran Ministry of Health and Medical Education.

The study protocol was approved by the Research Ethic Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran.

RESULTS
There were 685 residents and 40 fellows who completed the questionnaires. Table 1 presents the baseline characteristics of the participants. Shahid Rajaie Hospital affiliated to Iran University of Medical Sciences and Qazvin Medical University had the highest and lowest participants, respectively.

Awareness of radiation protection among respondents
Overall awareness of the studied sample regarding radiation exposure risks/exposure was not satisfactory. Few participants (73 subjects, 10.1%) participated at educational courses offered by the universities for better performance with radiation at the beginning of their residency/fellowship training course (ie, formal training). Most of them (67%) advocated that in their journal clubs they did not have any discussion about radiation protection. Just 0.8% reported that such discussions are made regularly in their academic meetings and 30.5% reported this as being occasional. They reported that 17.9% of their professors usually did not respect international protocols such as ALARA (as low as reasonably achievable) strategy.

Only 21.7% of them were aware about radiation rules within pregnancy period.

A few numbers of residents/fellows (11.7%) were aware of any radiation protection guidelines in the textbooks and among them 38% used the Iranian Atomic Energy Organization guideline for radiation protection. Near to one-third (29.8%) of the survey respondents read some references about radiation impact on human life themselves. Among the respondents, only 7.9% reported that there was ‘a defined instruction document about dealing with radiation and its protection’ in their centre and most of them (65.8%) were not aware about radiation protection instruction in their centre. Only 22.5% of the subjects had this information that there is a known ‘radiation protection expert’ in their centres and only 14% of them had this person’s contact details (eg, phone number) in emergency situations. Only 8% of the participants had information about the amount of radiation they received during the preceding year.

Radiation protection devices
The state of using protective devices was as follows: lead apron (90.3%), lead glasses (43.7%), thyroid collars (83.9%), lead

<table>
<thead>
<tr>
<th>Table 1 Basic characteristics of the participants</th>
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<tbody>
<tr>
<td>Gender*</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Residency/ fellowship</td>
</tr>
<tr>
<td>Cardiology resident</td>
</tr>
<tr>
<td>Radiology resident</td>
</tr>
<tr>
<td>Interventional cardiology fellow</td>
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<tr>
<td>Electrophysiology fellow</td>
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<tr>
<td>Interventional radiotherapy fellow</td>
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<tr>
<td>Paediatric cardiology fellow</td>
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<tr>
<td>Heart failure fellow</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Residency year</td>
</tr>
<tr>
<td>First year</td>
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<td>Second year</td>
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<tr>
<td>Third year</td>
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<tr>
<td>Fourth year</td>
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<tr>
<td>Total number of residents, excluding fellows</td>
</tr>
</tbody>
</table>

*Data were available in only 580 subjects (145 individuals did not disclose their gender).
shields (90.3%) and radiation dosimetry badge (60.1%). Less than 7% of the participants had personal apron. About 48.7% used lead barrier and only 3.4% knew that safety of their using apron were checked, and 6.5% of them reported that their aprons were not checked at all. In catheterisation laboratories, only apron and thyroid collars were regularly used at any intervention, but not radiation glasses or shields. In radiology departments, only apron, but not thyroid collar, was regularly used.

**Blood tests**

Only <4% (3.7%) of the participants reported that blood cells checking (complete blood count (CBC)) had been performed in their educational centres and 18.1% of them personally checked their CBC and just 27.3% remembered the date of the last CBC checking.

**Radiation safety awareness and practice between trained and untrained participants**

Table 2 presents comparison of the studied variables between two groups of residents/fellows, those who received formal training regarding radiation safety at their university and those who did not receive such training. Residents and fellows who had participated in radiation exposure training courses in their centres before radiation exposure had better performance regarding awareness of radiation dealing instructions, knowing safety experts of their centres and their contact information, date of last CBC checking, use of radiation shield, studying about disadvantages of radiation on health and safety protocols in their centres.

**Role of didactic activities**

Table 3 depicts the role of conducting didactic activities (including journal clubs, morning reports or any scientific meeting) about radiation safety.

**DISCUSSION**

Radiation exposure might lead to major adverse impacts on clinical practitioner, especially clinical cardiologists and radiologists. Cardiology and radiology residents/fellows are exposed to higher levels of radiation than faculty members due to their educational role in healthcare system.1 8 Suitable training for radiation protection in most of cases can reduce these major impacts.9

Findings of the present survey showed that awareness of Iranian cardiology/radiology residents/fellows about radiation exposure and safety issues was not satisfactory. They have received inadequate training for radiation protection. Only about 10% of the sample participated at formal training programmes held by their universities at the beginning of their academic training course. Regarding primary awareness, <10% of the respondents reported that they received instructions for radiation safety in their educational centres and most of them had no awareness about the presence of ‘a radiation safety expert’ in their centres. Most of them did not report receiving defined and useful trainings for radiation safety within their didactic activities such as journal clubs. They reported that they did not have any challenge or guidance about radiation safety, and unfortunately in practice part, 17.9% of their professors/instructors did not adhere to international safety protocols such as ALARA. We agree with suggestion of other authors that ALARA, as an international protocol for radiation protection, must be implemented in most clinical radiation-based training courses for reducing radiation-related risks and impacts.7 Increasing the distance between resident/fellow and source of radiation exposure, decreasing the time of the procedure and use of lead shielding are known as the three basic concepts of ALARA protocol.2 10 More than lead shielding, dosimeters of cardiologists must be located outside of the lead apron5 and assessed every month for risk of occupational radiation and maintain radiation level in control limit.4 Appropriate use of lead shielding can make cardiac catheterisation a safe procedure for clinical cardiologists in catheterisation laboratories.4 11

The studied sample did not use adequately protection devices (eg, radiation shields, radiation dosimetry badge, radiation glasses and other devices) during their practice and education. One exception was apron, which was used in more than 90% of the respondents. Less than 10% had personal apron. Considering these two facts, it is concluded that apron is widely

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison of safety radiation issues and usage of protective devices between two groups of trained and untrained Iranian radiology/cardiology residents/fellows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (N=725)</td>
</tr>
<tr>
<td>Voluntary studying about radiation safety</td>
<td>219 (30.2%)</td>
</tr>
<tr>
<td>Knowledge about the rules of radiation safety in pregnancy</td>
<td>157 (21.6%)</td>
</tr>
<tr>
<td>Existence of radiation safety instruction at the centre</td>
<td>58 (8%)</td>
</tr>
<tr>
<td>Studying the centre’s radiation safety instruction</td>
<td>19 (2.6%)</td>
</tr>
<tr>
<td>Knowing the centre’s radiation safety expert</td>
<td>163 (22.5%)</td>
</tr>
<tr>
<td>Knowing the contact details of the centre’s radiation safety expert</td>
<td>102 (14.1%)</td>
</tr>
<tr>
<td>Apron usage</td>
<td>656 (86.4%)</td>
</tr>
<tr>
<td>Lead glasses usage</td>
<td>318 (43.9%)</td>
</tr>
<tr>
<td>Thyroid collar usage</td>
<td>609 (84%)</td>
</tr>
<tr>
<td>Radiation dosimetry badge usage</td>
<td>269 (37.1%)</td>
</tr>
<tr>
<td>Radiation shield usage</td>
<td>353 (48.7%)</td>
</tr>
<tr>
<td>Knowledge about the last time lead apron was checked regarding its safety</td>
<td>71 (9.8%)</td>
</tr>
<tr>
<td>Having personal lead apron</td>
<td>50 (6.9%)</td>
</tr>
<tr>
<td>Knowledge about radiation dose exposed during the last year</td>
<td>54 (7.5%)</td>
</tr>
<tr>
<td>CBC checking by the medical centre</td>
<td>27 (3.7%)</td>
</tr>
<tr>
<td>Personal CBC checking</td>
<td>133 (18.4%)</td>
</tr>
<tr>
<td>Knowledge about the time of the last CBC obtained</td>
<td>198 (27.3%)</td>
</tr>
</tbody>
</table>

CBl complete blood count.
distributed at catheterisation laboratories and radiology services and residents did not need to buy that. Similar results have been found in other studies and support our results. In most of the related studies, residents/fellows believed that they did not have adequate training for using noted devices.4,12

The obtained results demonstrated that those subjects who had received formal training about radiation risks and protection had significantly better awareness and performance in some aspects compared with those who did not receive such trainings. The same status has been reported by previous authors in some other countries.7,13 In developed countries such as the USA, according to the American College of Cardiology report, only 19% of cardiologists attended training programmes for awareness about radiation risks and control of them.2 Currently, in Iran, there is no standard and uniform training course for residents to be held by all universities. Based on these findings, it is suggested that a comprehensive instruction to be prepared by responsible organisation or ministries and reviewed by experts and clinicians.

Although protective devices and techniques can reduce risk of radiation exposure in cardiologists,4,12 cardiology and radiology residents/fellows are exposed to greater levels of radiation dose compared with faculty members due to the nature of educational purposes among trainees.14 On the other hand, cardiology and radiology residents/fellows need more and adequate training courses regarding radiation protection for covering this matter and prepare them for safe and ensure achieving their optimal educational goals.

Some researchers reported that in addition to inadequate training, some other causes such as discomfort of using protective devices and fear of impairment of image quality due to reduced time of radiation process were responsible for lower awareness of cardiology and radiology residents/fellows.3

The present survey had some limitations; first, we used only qualitative items and further studies with quantitative measurement of radiation amount and its association with the level of dangerous outcomes are needed. Second, we did not classify the study participants according to the level of their educational centres. Third, since there is no uniform national safety protocols at the moment, the reasons why residents/fellows do not comply with safety regulations cannot be compared between different universities. We propose that after establishing a national safety protocol for health care personnel, further studies should be done in order to determine the effectiveness of the established protocol.

The limitation we encountered was that about 20% of the target study population did not respond and did not fill out the questionnaires. Unfortunately, we did not have access to them to find out the reasons why they did not respond.

**CONCLUSION**

Generally, awareness/practice of Iranian cardiology/radiology residents/fellows about radiation exposure safety issues is not acceptable currently. Those who received formal training courses at the beginning of their academic centres about the safety measures, as expected, had better knowledge compared with those who did not receive such trainings. This finding can be used as a document for respective authorised bodies to design and implement a comprehensive and uniform radiation practice guideline to all medical universities throughout the country and oblige the universities to train their residents/fellows. Although there is general guideline compiled by the AEOI, studying that is not obligatory and is not included in the curriculum of residents. Regarding increasing rate of interventional procedures in medicine, these measures seem to be inevitable in short term to decrease any hazardous adverse effects of radiation exposure.

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Contributors HA-S: concept and data collection. MS: literature search and writing draft. MHN: supervision. HV: editing and critical revision of the article. HS: research design.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

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