A study to assess the knowledge and practice of medical professionals on radiation protection in interventional radiology

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Abstract

Objective: Ionizing radiation has been extensively used in medical procedures throughout the world. Such interventional radiological procedures could result in occupational exposure that needs urgent control. Therefore, MPs (medical professionals) should receive education and appropriate training on occupational radiation protection. In this context, the present study is aimed to investigate the MPs' knowledge and practice regarding radiation protection principles during interventional radiological procedures.

Material and Methods: A descriptive questionnaire-based study was carried out among 215 MPs involved in interventional fluoroscopy procedures. The practice of 31 MPs was studied using a checklist based on ALARA principles and ICRP guidelines.

Results: A total of 43.3% and 45.1% answered correctly for knowledge and practice. However, the difference between radiation protection knowledge and practice between the physicians and nurses was statistically significant. The knowledge and practice survey of MPs demonstrated that nurses rarely adhered to radiation-protection measures.

Conclusion: The present study reflects the lack of knowledge and practice concerning radiation protection concepts among the nurses. This deficiency needs to be resolved by periodic practical radiation protection courses in the curriculum of medicine.

Key words: Education; knowledge; medical professionals; practice, radiation protection

Introduction

The use of interventional X-ray procedures has been continuously increasing since 1950; the investigators reported a dramatic increase in the number and frequency of medical-related exposures.1 Medical professionals (MPs) are exposed to both primary and scattered radiation during interventional procedures. The use of fluoroscopy has rapidly increased, resulting in an increased exposure to radiation. The exposure to ionizing radiation is a public health concern. However, the work-related hazard has not been fully addressed.2-4 This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

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Access this article online

Quick Response Code:  
Website: www.ijri.org
DOI: 10.4103/ijri.IJRI_333_19


Received: 06-Aug-2019 Revised: 31-Aug-2019  
Accepted: 28-Jan-2020 Published: 30-Mar-2020
various radiological procedures. Particularly, there is a concern regarding the occupational exposure of MPs involved in the interventional radiological procedures, especially when the presence of MPs is mandatory in the radiation area during radiation exposure. Although interventional radiology is associated with low-dose radiation, however, the potential damages of radiation during fluoroscopically guided and CT-guided procedures in the interventional laboratory are significant on the MPs, and, particularly, the nurses.

Numerous interventional medical imaging procedures can potentially expose the workers to the low-energy radiation which may cause biological stochastic effects on the MPs. Stochastic effects refer to the mutations which can potentially lead to cancers or genetic disorders. The primary basis for estimating the cancer risks due to the ionizing radiation exposures are the epidemiological studies on the Japanese atomic bomb survivors who were primarily exposed to high dose rates. The risks of radiation associated with low-dose exposures of MPs through radiological procedures should be also evaluated. Some studies report an excess risk of cancer among MPs due to low-dose exposures.

Some studies have addressed the occupational exposure-induced cancer rate and mortality among radiation workers. The National Council on Radiation Protection and Measurement (NCRP) reported a decrease of occupational exposure in an effective dose per individual in the United States, while the number and frequency of medical exposures were increased. Most of the obtained occupational effective dose values are well below the International Commission on Radiological Protection (ICRP) dose limits; however, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCERAR) reported that only a few countries have provided the data on interventional occupational exposures. Moreover, several studies have observed the annual effective dose and the percentage of measurable exposures on radiation workers. According to the UNSCEAR report, during the interventional procedures, the average annual effective doses are 1.6 mSv and 3.1 mSv for MPs and radiation workers, respectively. This report demonstrates the necessity to consider the safety of MPs involved in the interventional radiological procedures.

In ICRP Report No 118, the equivalent dose limit for the eye lens for occupational exposure of radiation workers was reduced from 150 mSv year$^{-1}$ to 20 mSv year$^{-1}$ . Some of the earlier retrospective cohort studies reported the excess risk of cataract among the radiologic technologists assisting in interventional radiological procedures.

It is recommended that healthcare workers can reduce the risks of radiation using various standard principles such as ALARA, which consist of three important parts: time, distance, and shielding. According to the ICRP recommendation, occupational radiation protection can be achieved by applying three main principles: justification, optimization, and dose limitation. MPs are continuously exposed to the ionizing radiation; therefore, they must receive proper education and training to minimize their occupational dose. This study is aimed to survey the knowledge, practice, and the factors affecting the practices of MPs concerning the radiation protection regulations during the interventional fluoroscopy procedures.

**Material and Methods**

The main purpose of this descriptive questionnaire-based study was to evaluate the knowledge and practice of MPs. The knowledge of 215 medical professionals (MPs) participating in the C-Arm (Technix, TCA 6) fluoroscopically-guided procedures including 174 nurses, and 41 physicians (urologist, orthopedics, surgery, neurologists, and radiologist) was evaluated by a questionnaire [Tables 1 and 2]. The questionnaire encompassed two major parts including various questions on radiation protection principles. The first part was related to demographic information such as the participant’s age, sex, and work experience [Table 1]. The second section consisted of 17 questions [Table 2] testing their knowledge on radiation protection principles. Furthermore, the practice of 31 MPs (24 nurses and 7 physicians) involved in the interventional fluoroscopy procedures was studied by a checklist of questions [Table 3]. The checklist included ten questions on radiation protection practice provided based on the ICRP guidelines and the ALARA principles.

**Statistical analysis**

The validity of the questionnaire was assessed by three radiologists and medical physicists, and its reliability was determined by the test-retest (Cronbach’s alpha = 0.88). After collecting the data, statistical analyses were carried out using SPSS 16 software through the parametric (Student’s t-test) and nonparametric (Mann–Whitney U and Kruskal–Wallis) tests. All the values are rounded by two decimal places. Each participant signed a consent form, and the study was reviewed and approved by the ethical committee of Yasuj University of Medical Sciences.

**Results**

The correct answer rates (CAR) of the knowledge and practice parts of MPs were separately determined for each question [Tables 2 and 3]. Our findings indicated that CAR of the practice and knowledge of the nurses was significantly lower than those of the physicians ($P = 0.007$, $P = 0.001$, respectively). The CAR of the knowledge in terms of the operator distance and time was 50.6% and 52%, respectively. Concerning the place of the personal
The majority (88.3%) of MPs were aware that fetuses or pregnant mothers are more sensitive to radiation compared to the other patients. Nearly 16% of the MPs were familiar with the organ radiosensitivity during interventional radiology. Furthermore, only 19 respondents knew about the occupational dose limits for MPs according to ICRP recommendations.

According to the first part of the questionnaire, 134 nurses (77%) did not pass a radiation protection course during their undergraduate and postgraduate studies or at their workplace. In the case of the physicians, the condition was better although 34% did not receive such education during their studies. Moreover, none of the MPs had any practical training in their workplace or during their education on radiation safety. Our findings showed that the highest rate of proficiency about radiation protection was found among the MPs that received a radiation protection course in the workplace or their educational curriculum ($P = 0.041$). Among the physicians, the radiologists and surgical specialists had the highest and lowest correct answers rates, respectively ($P = 0.03$).

According to the first part of the questionnaire, one of our most considerable findings was that 17 nurses had radiophobia and four female nurses withdrew to participate in fluoroscopically-guided procedures.
Table 2: The questionnaire applied to assess the knowledge of 215 medical professionals, CAR%(N): CAR%: Correct Answers rate, N: Number of Correct Answers, The percent and number of physicians and nurses who answered the questions correctly are shown in the third column separately.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Questions</th>
<th>CAR%(N)</th>
<th>P: Physicians Nu: Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (ALARA)</td>
<td>1. What is the most important factor in radiation protection that radiation workers should consider according to ALARA?</td>
<td>50.69 (109)</td>
<td>P: 60.97 (25) Nu: 48.27 (84)</td>
</tr>
<tr>
<td>Time (ALARA)</td>
<td>2. What does the “time principle” mean in ALARA?</td>
<td>52.09 (112)</td>
<td>P: 56.09 (23) Nu: 51.14 (89)</td>
</tr>
<tr>
<td>Shielding (ALARA)</td>
<td>3. Where the personal dosimeter must be placed?</td>
<td>87.44 (188)</td>
<td>P: 73.17 (30) Nu: 90.8 (158)</td>
</tr>
<tr>
<td></td>
<td>5. On what conditions the lead gloves must be used?</td>
<td>58.13 (125)</td>
<td>P: 85.36 (35) Nu: 51.72 (90)</td>
</tr>
<tr>
<td></td>
<td>6. On what conditions the thyroid shields must be used?</td>
<td>24.18 (52)</td>
<td>P: 39.02 (16) Nu: 20.68 (36)</td>
</tr>
<tr>
<td></td>
<td>7. On what conditions the leaded aprons need to be used?</td>
<td>25.11 (54)</td>
<td>P: 36.58 (15) Nu: 22.41 (39)</td>
</tr>
<tr>
<td>Justification</td>
<td>10. What is the meaning of Justification in radiation protection, in accordance with ICRP recommendations?</td>
<td>88.37 (190)</td>
<td>P: 87.80 (36) Nu: 88.5 (154)</td>
</tr>
<tr>
<td>Optimization</td>
<td>11. What is the implication of optimization in radiation protection according to ICRP recommendations?</td>
<td>92.09 (198)</td>
<td>P: 92.68 (38) Nu: 91.95 (160)</td>
</tr>
<tr>
<td>non-stochastic effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organs radiosensitivity</td>
<td>15. Which organs are more sensitive to ionizing radiation?</td>
<td>16.27 (35)</td>
<td>P: 43.90 (18) Nu: 9.77 (17)</td>
</tr>
<tr>
<td>Fetus or pregnancy</td>
<td>16. Which group of patients is the most radiosensitive to ionizing radiation?</td>
<td>88.37 (190)</td>
<td>P: 100 (41) Nu: 85.63 (149)</td>
</tr>
<tr>
<td>Position</td>
<td>17. What is the best place for medical staff to stay (close to the patient) in order to reduce the scattered rays?</td>
<td>25.58 (55)</td>
<td>P: 43.90 (18) Nu: 21.26 (37)</td>
</tr>
</tbody>
</table>

Discussion

The results of this study showed that only 47.7% of the participants were able to comprehend the concept of ALARA, although it is the basic principle of radiation protection. Nearly 88% of the physicians were familiar with the basic concepts of radiological procedures as a primary principle of the patients’ radiation protection. This finding confirms the ICRP reports expressing that some radiological procedures are prescribed without sufficient justification. Moreover, 8.8% of the MPs knew about the ICRP dose limit (a fundamental part of most radiation protection programs) and the fact that the purpose of individual radiation monitoring is to ensure that the dose limits are not exceeded.

The significance of radiation-sensitive organ shielding in reducing the equivalent and effective dose has been already approved. According to the basic principles of radiation protection, the protective leaded aprons and thyroid shields must be periodically applied during the interventional procedures; however, most of the MPs ignored the role of the personal protective devices in controlling the occupational radiation exposure. Flôr and colleagues showed that technicians did not even use these personal protective devices as they found that such equipment heavy and uncomfortable (particularly leaded aprons). Among the personal protective devices, MPs exhibited the lowest knowledge and the weakest practice for the leaded eyewear, while the risk of exceeding the annual lens dose limit can be dramatically reduced upon using leaded eyewear shields during the interventional radiological procedures. It should be mentioned that ICRP recommended 20 mSv year⁻¹ as a dose limit for the eyes lens, averaged over defined periods of 5 years, with no annual dose in a single year exceeding 50 mSv. The participant’s awareness of the right place of personal dosimeter (87.4%) was appropriate, but the MPs’ practice...
It is generally known that significant amount of radiation is scattered when the radiation flows through the patient body; although, in interventional radiology, the MPs spend a substantial amount of time inside the X-ray rooms with significant radiation intensity. Only 37 (17.2%) of the MPs knew that radiation scattering from the patients’ bodies is one of the prominent sources of radiation exposure. Another important finding is that 17 (54.8%) of the nurses suffered from radiophobia and some of the female nurses preferred to avoid participating in the interventional fluoroscopy procedures, which might be due to the rumors or lack of precise knowledge on the radiobiological effects of radiation. A similar finding has been observed among the nurses investigated in the work of Dianati et al. It seems that the main reason for their reluctance to assist in the radiological examinations was the lack of practical radiation protection education and training. Our results also indicated that the MPs are not entirely aware of the radiobiological effects of radiation, which is in agreement with a previous study carried out by Alotaibi et al.

Several studies have indicated the poor radiation protection awareness of the MPs. There are also some other researchers that reported proper awareness of the MPs. Such discrepancies could be due to the participants and the research methodology. According to the results of the current study, the CAR of knowledge toward radiation protection was 57.81%, 39.88%, 43.30% among the physicians, nurses, and all MPs, respectively. This value was 40% and 39% in the studies carried out by Keijzers et al. and Soya et al., respectively. The lack of effective radiation protection practice was also observed among the nurses, which can be attributed to the insufficient training in the field of radiation protection. In summary, our research indicates that the lack of knowledge and practice among the nurses makes them unable to protect the patients and themselves against ionizing radiation. It may indicate a deficiency in the educational training of nurses since this study, in addition to many others, showed that most of the nurses had not passed any theoretical course or practical training in radiation protection at the universities or hospitals.

**Conclusion**

The current study showed that many medical professionals (MPs) are not aware of the necessary scientific information about the radiation protection concepts and practices which may lead to serious radiation-related errors. The potential benefits of MPs, as active players in radiation protection, need to be emphasized in universities and hospitals, where the curriculum contents in radiation sciences are insufficient. Additional training is also recommended in medical schools or hospitals.

**Financial support and sponsorship**

The study was supported by Yasuj University of Medical Sciences, Yasuj, Iran.

**Conflicts of interest**

There are no conflicts of interest.
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