

Intensive Care Nurses' Knowledge of Radiation Safety and Their Behaviors Towards Portable Radiological Examinations

Mansoor Dianati¹; Azita Zaheri^{1*}; Hamid Reza Talari²; Fateme Deris³; Sara Rezaei¹

¹Department of Medical-Surgical Nursing, Kashan University of Medical Sciences, Kashan, IR Iran

²Department of Radiology, Kashan University of Medical Sciences, Kashan, IR Iran

³Statistics Department, Shahrekord University of Medical Sciences, Shahrekord, IR Iran

*Corresponding author: Azita Zaheri, Department of Nursing Medical-Surgical, Kashan University of Medical Sciences, Kashan, IR Iran. Tel: +989137321369, E-mail: zaheriazita69@gmail.com

Received: September 6, 2014; **Revised:** September 27, 2014; **Accepted:** October 30, 2014

Background: Radiological examinations for patients who are hospitalized at intensive care units are usually performed using portable radiography devices. However they may require knowledge and safety precautions of nurses.

Objectives: The aim of the study was to investigate ICU nurses' knowledge of radiation safety and their behaviors towards portable radiological examinations.

Materials and Methods: In total, 44 intensive care nurses were recruited for this cross-sectional descriptive study using census sampling during April and May 2014. The study setting was at intensive care units of Shahid Beheshti Hospital of Kashan, Iran. An eleven-item questionnaire and a five-item checklist were used for evaluating nurses' radiation protection knowledge and behaviors, respectively. An expert panel consisting of ten nursing and radiology faculty members confirmed the content validity of the questionnaire and the checklist. Moreover, a Geiger-Müller counter was used for measuring ionizing radiation during portable radiological examinations. Study data were analyzed using the SPSS software version 13.0. Mean, standard deviation, frequency and one-sample t test were used for description of the data. The level of significance was set at below 0.05.

Results: The mean of participants' radiation protection knowledge was 4.77 ± 1.38 . The most prevalent radiation protection behavior of nurses was leaving the intensive care unit during portable radiological examinations. Only 6.8% of nurses stayed at the nursing station during radiological examinations. The highest dose of radiation was 0.11 micro Sievert per hour ($\mu\text{Sv/h}$), which was much lower than the highest permitted level of radiation exposure i.e. $0.25 \mu\text{Sv/h}$.

Conclusions: Portable radiological examinations did not expose healthcare providers to high doses of ionizing radiation. Nurses' radiation protection knowledge was limited and hence, they require in-service education programs.

Keywords: Radiation Protection; Knowledge; Behaviors; Nurses

1. Background

Ionizing radiation has been increasingly used during the past decades for diagnosing and treating different medical conditions (1). However, besides its diagnostic and therapeutic effects, ionizing radiation is also associated with different side effects. Severity of side effects varies with the dose, for which there is threshold value. Beyond certain thresholds, radiation can impair the functioning of tissues and/or organs and can produce acute effects such as skin redness, hair loss, radiation burns or acute radiation syndrome. These effects are more severe at higher doses and higher dose rates. For instance, the dose threshold for acute radiation syndrome is about 1000 millisievert per year (mSv/yr) (2).

If the dose is low or delivered over a long period of time (low dose rate), there is greater likelihood for damaged cells to successfully repair themselves (3). However, long-term effects may still occur if cell damage is repaired but incorporates errors, transforming an irradiated cell that still retains its capacity for cell division. This transforma-

tion may lead to cancer when years or even decades have passed. Effects of this type will not always occur, but their likelihood is proportional to the radiation dose. This risk is higher for children and adolescents, as they are significantly more sensitive to radiation exposure than adults (3).

Epidemiological studies on populations exposed to radiation showed a significant increase of cancer risk at doses above 100 mSv/yr (4).

Accordingly, healthcare professionals particularly nurses are at a great risk for being exposed to harmful effects of ionizing radiation (5).

One of the most common indications of radiological examinations is for patients who are hospitalized at intensive care units (ICU). The patients in these units are usually connected to different medical devices and have many catheters and tubes in place and hence, they cannot be transferred to the radiology unit for undergoing radiological examinations (6). Accordingly, radiological

examinations in ICUs are usually performed by using portable radiography devices. Portable radiological examinations dramatically increase nurses' exposure to ionizing radiation (7).

Being aware of the risks of ionizing radiation as well as the probability of radiation exposure and effective strategies for radiation protection is of paramount importance for all healthcare providers particularly those who work in ICUs. Without having such awareness, healthcare professionals may either have unnecessary fear and anxiety over radiation exposure or they may fail to adopt measures to protect themselves from the adverse effects of ionizing radiation (8). The highest permitted level of occupational radiation exposure is 0.25 micro Sievert per hour ($\mu\text{Sv/h}$) or 20 millisievert per year (mSv/y) (9). However, most hospital staff wrongly believe that all doses of ionizing radiation are harmful to humans and hence they have fear over portable radiological examinations (7). The consequent overprotection or under protection may cause considerable damage to patients and healthcare providers' health.

Studies have shown that nurses have limited knowledge of radiation safety, exposure and protection (8). Rassin et al. evaluated radiation knowledge and attitude of 68 physicians and 76 nurses who were working in high-exposure clinical settings. They found that more than 70% of physicians and nurses had limited knowledge regarding hazards of radiation, amount of environmental radiation of each radiological examination, and radiation protection strategies (10). Amiri et al. also investigated a group of Iranian radiology technicians' radiation protection strategies. They found that 94.7% of the technicians adopted self-protection strategies while only 26.3% of them employed strategies for protecting patients and other healthcare professionals (11), however, in our literature review no study describing Iranian nurses' knowledge was found.

Reliable sources indicated that there is a knowledge gap in the area of ICU nurses' knowledge and behavior concerning protection against portable radiation. Moreover, there are major conflicts between Iranian nurses and hospital administrators regarding the safest place during portable radiological examinations. Accordingly, this study was conducted to fill this knowledge gap and to provide further evidence regarding nurses' radiation protection knowledge and behavior.

2. Objectives

The aim of the present study was to investigate ICU nurses' knowledge of radiation safety and their behaviors towards portable radiological examinations.

3. Materials and Methods

This cross-sectional descriptive study was conducted during April and May 2014. The study setting was the medical, surgical, and the trauma ICUs of Shahid Be-

heshti Hospital, Kashan, Iran. In total, there were 22 beds in these three ICUs at the time of the study. All 45 ICU nurses who were working in the study setting were recruited in the study using the census method.

We used a demographic questionnaire, a radiation protection knowledge questionnaire (RPKQ), and a checklist, all of which were researcher-made. The demographic questionnaire consisted of five questions related to nurses' age, gender, marital status, education level, and ICU work experience. The RPKQ contained eleven multiple-choice questions on nurses' knowledge of X-ray radiation safety. Right and wrong answers were specified by one and zero, respectively. Accordingly, the total score of the RPKQ was 0-11. Scores less than 5 were considered as low knowledge.

We also used a checklist for identifying nurses' protective measures against radiation exposure. The five items of the checklist were: going out of the unit, going to the break room, staying at the nursing station, standing behind a lead apron, and using protective equipment.

Additionally, we used a Geiger-Müller counter (Summertown Co., USA) for measuring real-time ionizing radiation. This device detects and measures ionizing radiation and shows the dose of radiation on a built-in display. The unit of measurement is $\mu\text{Sv/h}$. Furthermore, mobile imaging machines were similar in all three sectors and quality control was performed by each department of the hospital at the start of each year.

An expert panel consisting of ten nursing and radiology faculty members was invited to assess the content validity of the RPKQ and the checklist. We asked them to rate the relevance, simplicity and clarity of the items. The means of total relevance, simplicity, and clarity scores were 0.99, 0.98, and 0.97, respectively. The content validity index of the instrument was 0.98. Moreover, the face validity of the instrument was assessed by asking ten practicing nurses to judge the readability, clarity, and comprehensibility of the items. The reliability of the instrument was evaluated by employing the test-retest method. Accordingly, ten practicing nurses were asked to complete the RPKQ twice with a two-week interval in between. The test-retest correlation coefficient was equal to 0.85.

In case of any portable radiological examinations during the present study, the second author (a trained nurse) referred to the study setting and used a Geiger-Müller counter to measure ionizing radiation at predetermined locations within the ICU. This device is annually calibrating at the Secondary Standard Dosimetry Lab (SSDL) located in Karaj city of Iran. The measurement locations were nurses' break room, nursing station, and behind a lead apron. Each location was studied three times. The mean of the three measurements was calculated and used for final data analysis. Moreover, the same researcher observed and documented nurses' radiation protection behavior during the concurrent measurement of radiation. At the end of the study, we invited the study participants to respond to the RPKQ. Nurses responded

to the items at the end of their shift in the presence of the second author.

3.1. Ethical Considerations

The University Review Board and Research Ethics Committee of Kashan University of Medical Sciences approved this study (approval letter no. 9380). The objectives of the study and existence of an observer were explained to all participants. They were all assured of the privacy of their personal information and signed a written informed consent form before participating in this study.

3.2. Data Analysis

Study data were analyzed using the SPSS software version 13.0. The mean, standard deviation, and percentage of nurses' radiation protection knowledge, the frequency of their radiation protection behaviors, and the mean of radiation dose were calculated for the final analysis. One-sample t test was used for comparing the mean radiation dose with the highest permitted level of occupational radiation exposure. The level of significance was set at below 0.05.

4. Results

In total, 45 nurses were recruited in the study, yet, 44 nurses replied to the study questionnaire completely. The response rate was 97.77%. Most of the study participants were females (90.90%). The age of study participants ranged between 25 and 45 years with a mean of 32 ± 5.81 years. The range and the mean of participants' work experience were 7.39 ± 3.89 and 1-15 years, respectively.

The mean of participants' radiation protection knowledge was 4.77 ± 1.38 . The highest and the lowest scores were 2 and 8, respectively. The highest and the lowest scored questions of the RPKQ were question numbers 4 and 8, respectively (Table 1). Table 2 shows nurses' radiation protection behaviors. We found that 37 nurses (84%) left the ICU and missed to monitor their patients during portable radiological examinations. Table 3 shows the findings of the radiation dosimetry at different locations within the three ICUs. The highest dose of radiation was related to the nursing station of the surgical ICU. The results of the one-sample t test revealed that the mean dose of radiation was significantly lower than the highest permitted level of occupational radiation exposure (P value < 0.001; Table 4).

Table 1. ICU Nurses' Radiation Protection Knowledge ^a

Items	Right Answers	Wrong Answers
How much is the highest permitted level of occupation radiation exposure?	14 (31.8)	30 (68.2)
What is the best place for installing barriers to protect nurses' against radiation?	13 (29.5)	31 (70.5)
What is the best material for manufacturing protective clothes?	30 (68.2)	14 (31.8)
How can we enhance our radiation safety?	34 (77.3)	10 (22.7)
Who is absolutely forbidden to radiation exposure?	20 (45.9)	24 (54.5)
How much are the dose and the quality of portable radiography compared with other imaging procedures?	23 (52.3)	21 (47.7)
What is the best protective equipment for nurses during portable radiography?	11 (25)	33 (75)
What is the safe distance from the source of radiation when performing portable radiography?	6 (13.6)	38 (86.4)
What is the best place for attaching the film badge when a nurse has worn a lead apron?	14 (31.8)	30 (68.2)
What are the best protective equipment in case of any environmental radiation exposure?	19 (43.2)	25 (56.8)
Which factor reduces conscious patients' exposure to radiation during portable radiography?	28 (63.6)	16 (36.4)

^a all of the values are present as No. (%).

Table 2. Emergency Care Unit Nurses' Radiation Protection Behaviors ^a

Behaviors	Values
Staying at the nursing station and monitoring patients through the central monitoring system	3 (6.8)
Going out of the unit	30 (68.18)
Going to the break room	7 (15.9)
Standing behind a lead apron	4 (9.09)
Using protective equipment	0 (0)

^a all of the values are present as No. (%).

Table 3. The Doses of Radiation at Different Locations Within the Study Setting (μ Sv/h)

Location	Unit		
	ICU 1	ICU 2	ICU 3
Nurses' break room	0.00	0.00	0.00
Nursing station	0.11	0.10	0.00
Behind a lead apron	0.00	0.01	0.00

Table 4. Comparing the Mean Dose of Radiation With the Highest Permitted Level of Occupational Radiation Exposure

Variable	Number of Place	Mean \pm SD	Min	Max	Normal	P Value
Real-time ionizing radiation ^a	9	0.02 \pm 0.04	0	0.11	0.25	< 0.001

^a Micro sievert/hours.

5. Discussion

This study examined ICU nurses' radiation protection knowledge and practice. The study findings revealed that our participating nurses had limited knowledge of radiation protection. Rassin et al. also reported that while more than 70% of physicians and nurses personally believed that they had great radiation protection knowledge, their knowledge was poor to moderate (10). The nurses' limited radiation protection knowledge can be attributed to limited college-based and in-service educations about radiation safety and protection. Aps (12), Salti and Whaites (13) and Ilguy et al. (14) also conducted three studies in different countries and found that dental practitioners had limited radiation safety and protection knowledge. However, Slechta, Reagan and Shah found that radiology technicians' knowledge of X-ray radiation protection was 75-82% (13-16). The discrepancies among the findings of different studies can be attributed to differences in the settings, samples, and data collection instruments of the studies.

We also found that most of the participating nurses left the ICU during portable radiological examinations. In this study leaving the ICU was the most common radiation protection strategy. This finding can be related to their limited knowledge of safe distance from the source of radiation during portable radiological examinations. However, Flor and Gelbcke found that nurses who worked in catheterization laboratories did not even use the basic safety equipment because they considered such equipment as heavy and uncomfortable (17). The conflict between our findings and the findings of Flor and Gelbcke can be attributed to the fact that catheterization nurses are constantly exposed to radiation and hence, they underestimate the risks of ionizing radiation and ignore the importance of using safety equipment. Moreover, they may have limited radiation protection knowledge.

The study findings also revealed that only three nurses out of the 44 participating nurses stayed at the nursing station and continued monitoring patients during radiological examinations. Nurses who leave the ICU during portable radiological examinations may fail to diagnose patients' accidental disconnection from mechanical ventilation devices. Such accidental disconnection can cause potential complications such as hypoxia, increased length of hospital stay, and increased mortality rate (18).

We also found that the dose of radiation in the study setting was significantly lower than the highest permitted level of radiation exposure. Cupitt et al. also reported the same findings (5). Similar findings of different studies in this area demonstrate that the dose of radiation during

portable radiological examinations in different locations of clinical settings is probably lower than the highest permitted level. Accordingly, healthcare providers' fear and anxiety over radiation exposure is unnecessary.

The findings of this study may guide nurses about the correct behaviors during portable radiological examinations. Eventually these actions may lead to saving time for patient care at the ICU.

Some limitations may be noted when reading the results of the present study. This study was performed only in one medical center and the study sample size was small. Furthermore we used an analog dosimeter, which may not be as accurate as the digital version. Future studies with larger sample sizes and use of digital dosimeters may overcome these limitations.

The study findings indicate that portable radiological examinations do not expose healthcare providers to high doses of ionizing radiation. Accordingly, clinical settings, which have been designed and organized according to proper safety standards, can be considered safe and free from ionizing radiation during portable radiological examinations.

Acknowledgements

We would like to thank and honor all nurses who assisted us with this research. Also, we specially thank our professors and authorities, who took part in the validity of this study.

Authors' Contributions

Mansoor Dianati, Azita Zaheri and Hamid Reza Talari were all responsible for the study conception and design. Azita Zheri performed the sampling and data collection. Fateme Deris performed the data analysis and prepared the draft of the manuscript. Mansoor Dianati critically revised the paper for important intellectual content and supervised the study.

Funding/Support

This study was part of a M.Sc. thesis funded by the Deputy of Research of Kashan University of Medical Sciences and Health Services; grant number: 9380.

References

1. Compagnone G, Angelini P, Pagan L. Monitoring of the medical radiological exposures of the population of the Emilia-Romagna Region. *Radiol Med.* 2006;**111**(3):469-80.
2. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radia-

- tion-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol.* 2001;**176**(2):289-96.
3. Fazel R, Krumholz HM, Wang Y, Ross JS, Chen J, Ting HH, et al. Exposure to low-dose ionizing radiation from medical imaging procedures. *N Engl J Med.* 2009;**361**(9):849-57.
 4. Amundson SA, Bittner M, Meltzer P, Trent J, Fornace AJ. Biological indicators for the identification of ionizing radiation exposure in humans. *Expert Rev Mol Diagn.* 2001;**1**(2):211-9.
 5. Cupitt JM, Vinayagam S. Radiation exposure of nurses on an intensive care unit. *Brith J Anaesth.* 2001;**56**(2):183.
 6. Cruz J, Ferra M, Kasarabada A, Gasperino J, Zigmund B. Evaluation of the Clinical Utility of Routine Daily Chest Radiography in Intensive Care Unit Patients With Tracheostomy Tubes: A Retrospective Review. *J Intensive Care Med.* 2014.
 7. Siddiqui SS, Jha A, Konar N, Ranganathan P, Deshpande DD, Divatia JV. Radiation exposure among medical professionals working in the Intensive Care Unit. *Indian J Crit Care Med.* 2014;**18**(9):591-5.
 8. Amis ES, Jr, Butler PF, Applegate KE, Birnbaum SB, Brateman LF, Hevezi JM, et al. American College of Radiology white paper on radiation dose in medicine. *J Am Coll Radiol.* 2007;**4**(5):272-84.
 9. George J, Eatough JP, Mountford PJ, Koller CJ, Oxtoby J, Frain G. Patient dose optimization in plain radiography based on standard exposure factors. *Br J Radiol.* 2004;**77**(922):858-63.
 10. Rassin M, Granat P, Berger M, Silner D. Attitude and knowledge of physicians and nurses about ionizing radiation. *J Radiol Nurs.* 2005;**24**(2):26-30.
 11. Amiri F, Tohidnia M, Hormozi Z. [Principles of radiation protection in the ICU of Imam Reza Hospital of Kermansha]. . *The proceeding of the first annual congress of Kermansha University of Medical Sciences.* 2011;**10**.
 12. Aps JK. Flemish general dental practitioners' knowledge of dental radiology. *Dentomaxillofac Radiol.* 2010;**39**(2):113-8.
 13. Salti L, Whaites EJ. Survey of dental radiographic services in private dental clinics in Damascus, Syria. *Dentomaxillofac Radiol.* 2002;**31**(2):100-5.
 14. Ilguy D, Ilguy M, Dincer S, Bayirli G. Survey of dental radiological practice in Turkey. *Dentomaxillofac Radiol.* 2005;**34**(4):222-7.
 15. Slechta AM, Reagan JT. An examination of factors related to radiation protection practices. *Radiol Technol.* 2008;**79**(4):297-305.
 16. Shah AS, Begum N, Nasreen S, Khan A. Assessment of radiation protection awareness levels in medical radiation science technologists-a pilot survey. *J Post Med Inst.* 2011;**21**(3):416-22.
 17. Flór R, Gelbcke F. Radiation protection and the attitude of nursing staff in a cardiac catheterization laboratory. *Texto Contexto-Enferm.* 2013(2):416-22.
 18. Divatia J, Bhowmick K. Complications of endotracheal intubation and other airway management procedures. *Indian J Anaesth.* 2005;**49**(4):308-18.