Original article

Assessment of awareness of radiation protection and knowledge of radiation dose among 5th year medical students and radiology residents at Maharaj Nakorn Chiang Mai Hospital, Thailand

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Objectives Our study aimed to assess the awareness of radiation protection and knowledge of radiation dose of 5th year medical students and radiology residents.

Methods Forty-seven 5th year medical students and 18 radiology residents participated in this survey during July 10-17, 2019. Participation was voluntary and the identity of the respondents was kept anonymous. The participants were asked to complete the questionnaire via Google forms within a period of 15 minutes.

Results The survey found that 48.9% of 5th year medical students and 61.1% of radiology residents felt they had sufficient knowledge of ionizing radiation protection. Counting one point for a correct answers and zero points for a wrong answer, the overall mean score of the 5th year medical students was 6.2 out of a possible 16 with a standard deviation of 2.2. The overall mean score of the radiology residents was 7.9 out of 16 with a standard deviation of 2.1. Only 14.9% of the medical students and 38.9% of the radiology residents knew about stochastic radiation damage. However, 57.4% of the medical students and 88.9% of the radiology residents did know about the "as low as reasonably achievable" (ALARA) concept. Fifty percent of the medical students did not know that MRI and ultrasound do not produce ionizing radiation.

Conclusion There is evidence of inadequate awareness of radiation protection and knowledge of radiation doses among both 5th year medical students and radiology residents at Maharaj Nakorn Chiang Mai Hospital, Thailand. To improve this situation, adding theoretical and practical modules to the standard curricula should be considered. **Chiang Mai Medical Journal 2020;59(4):197-205.**

Keywords: CXR, medical students, radiation dose, radiation protection

Introduction

The number of diagnostic imaging investigations that use ionizing radiation has increased over the past decade. Between 1996 and 2010, the use of computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and PET imaging have increased annually by 7.8%, 10.0%, 3.9%, and 57.0%, respectively (1). This indicates that there is a potential for unnecessary high radiation exposure among both patients and medical practitioners. The contribution to the total risk of cancer from radiation exposure during a CT scan depends on the scan type, frequency of use, radiation dose, and the individual's general health (2). Radiation side effects are a particular concern among young patients, especially children. Evidence has demonstrated that the use of a CT scan as part of a pediatric examination can increase the risk of developing leukemia and brain cancer (3,4).

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A review of previous research shows that radiology residents, radiography students, and medical students often have only a limited awareness of radiation protection and the radiation risks associated with imaging procedures (5-8). Furthermore, essential knowledge of radiation protection topics, e.g., regulations, patient susceptibility to radiation damage, radiation doses delivered in the normal radiological procedure, is generally lower among medical students than among radiology residents (6). This suggests that many individuals in the medical field may underestimate the consequences of not being protected from ionizing radiation even though they are regularly exposed to that radiation on a daily basis, e.g., that such exposure can lead to an increased risk of cancer and death. This lacuna in the medical education process demonstrates a need to evaluate the awareness of ionizing radiation prevention issues and knowledge about radiation dose among the trainee doctors and to develop appropriate methods to increase that knowledge.

Objectives

The main purpose of this study was to evaluate the awareness and knowledge of ionizing radiation prevention among 5th year medical students and radiology residents at Maharaj Nakorn Chiang Mai Hospital.

Methods

Data collection

This descriptive and analytic study, conducted between July 10-17, 2019, included a cross-sectional survey of 5th year medical students and radiology residents at Maharaj Nakorn Chiang Mai Hospital. The desired sample size was at least 45 of the 148 the 5th year medical students and at least 18 of the 23 radiology residents. Inclusion criteria were the 5th year medical students who had previously completed a radiology rotation during their 4th year at Maharaj Nakorn Chiang Mai Hospital and radiology residents currently training in the Radiology Department of Maharaj Nakorn Chiang Mai Hospital. Participants who failed to fully complete the questionnaire were excluded.

The research tool was a questionnaire about awareness and knowledge of ionizing radiation protection. The questions were similar to those in a previous study by Paolicchi (9). Prior to the survey, participants, all of whom were volunteers, were assured that the results of the questionnaire would be kept anonymous, stored in a database and used for research purposes only. To avoid bias, the participants were asked to complete the three-part online questionnaire within a 15-minute period via Google Forms (Survey software, Google LLC).

The questionnaire consisted of the following three parts:

Part 1. Personal data including gender, age, and perceived knowledge of radiation hazards.

Part 2. Awareness of radiation protection focusing on 1) patient's right to be informed about potential radiation damage; 2) awareness of patient sensitivity to radiation damage; 3) awareness of responsibility to avoid excessive radiation exposure; 4) knowledge of radiation dangers to individuals working in the field of radiation; 5) knowledge of the parts of the body that are more sensitive to radiation injury; 6) knowledge of the potential consequences of radiation damage; 7) understanding of the concept of dose optimization.

Part 3. Knowledge about radiation dosage with a focus on 1) average dose from a posteroanterior chest x-ray (considered a common reference unit to compare radiation exposure from different radiological examinations); 2) background radiation dose received by the general population; 3) lumbar spine x-ray dose; 4) mammography dose (bilateral, two projections for each side), 5) chest computed tomography dose; 6) pelvic magnetic resonance dose; 7) positron emission tomography-computed tomography dose; 8) abdominal ultrasound dose; 9) myocardial scintigraphy dose (9).

All questions in parts 2 and 3 were multiple-choice with five and six options, respectively. Each question had only one correct answer. In scoring, each question answered correctly was counted as one point and wrong answers were

counted as zero. The total points were used to calculate the mean score for each sample group.

Statistical analysis

SPSS version 24 was used for the statistical analysis. Categorical variables are given as percentages. Age is shown as mean, while other continuous variables are presented as mean ± standard deviation. Descriptive statistics were used to express the percentage of respondents choosing each option for every question about awareness and knowledge of ionizing radiation prevention. Analytical statistics were used to compare awareness and knowledge of ionizing radiation prevention between 5th year medical students and radiology residents of Maharaj Nakorn Chiang Mai Hospital and are presented as mean ± standard deviation.

Results

Of a total of 148 5th year medical students, 47 (31.8%) completed the questionnaire as did 18 of 23 radiology residents (78.3%). The mean age of the 5th year medical students and radiology residents was 22 and 28 years, respectively. Of the 5th year medical students answering the questionnaire, 27 (57.4%) were male as were 7 (38.0%) of the radiology residents.

In self-rating their knowledge level related to ionizing radiation-related risks prior to completing the questionnaire, 12 (25.5%) of the 5th year medical students rated their knowledge as insufficient, 11 (23.4%) rated it as good, and only one (2.13%) rated their knowledge as excellent. Among radiology residents, one (5.5%) rated their knowledge as insufficient, 6 (33.3 %) rated it as good and none rated their knowledge as excellent (Table 1).

Counting correct answers as one point and incorrect answers as zero points, the overall mean score of the 5th year medical students was 6.2 out of a possible 16 with a standard deviation of 2.2. For the radiology residents, the mean was 7.9 with a standard deviation of 2.1 The difference in total mean score between the two groups was statistically significant ($p < 0.05$).

Radiation protection awareness

Regarding radiation protection awareness (Part 2 of the questionnaire), 47 (100.0%) of the year medical students and 17 (94.4%) of the radiology residents showed awareness of the necessity to inform patients about the fundamentals of radiation damage. However, only 17 (36.2%) of the year medical students and 5 (27.8%) of the radiology residents knew which patients had the highest sensitivity to the radiation. Twenty-five (53.2%) of the 5th year medical students and 16 (88.9%) of the radiology residents knew that medical practitioners involved in using radiation must take responsibility for excessive exposure to radiation. Just over one fourth (23 or 28.9%) of the 5th year medical students and 12 (66.7%) of the radiology residents were aware that interventional cardiologists and radiologists have the highest potential for radiation exposure. Twelve (25.5%) of the 5th year medical students and 12 (66.7%) of the radiology residents were aware that the breast is the type of tissue most sensitive to radiation. Leukemia was acknowledged by only 7 (14.9%) of the 5th year medical students and 7 (38.9%) of the radiology residents to be a potential consequence

Table 1. Personal data and perceived knowledge of 5th year medical students and radiology residents

	5th year Medical students (n=47)	Radiology residents (n=18)	*p*-value
Age (mean; IQR)	22.2 (22-22)	28.2 (29-28.5)	< 0.001a
Gender (% male)	57.4	38.9	0.175
Perceived knowledge (%)			0.253
Excellent	2.1	0	
Good	23.4	33.3	
Sufficient	48.9	61.1	
Insufficient	25.5	5.6	

IQR; Q_3-Q_1, [a]*p*-value from Mann-Whitney U test

of exposure to stochastic radiation. Finally, 22 (46.8%) of the 5th year medical students and 16 (88.9%) of the radiology residents knew the definition of dose optimization (Table 2).

Table 2. Responses of participants regarding radiation protection awareness (Part 2 of the questionnaire). Correct answers are in bold

	5th year medical students (n=47)	Radiology residents	*p*-value
1. Is it necessary to inform patients about the risks related to the use of ionizing radiation for medical purposes?			**0.233**
Yes, Always	**100**	**94.4**	
Yes, but only patients younger than 18 years old	0	5.6	
Yes, but only patients who are going to have a CT scan	0	0	
Yes, but only patients younger than 65 years old	0	0	
No, Never	0	0	
2. Which of the following patients is the most sensitive to ionizing radiation?			0.415
1-year-old male	10.6	11.1	
1-year-old female	**36.2**	**27.8**	
20-year-old female	10.6	0.0	
40-year-old male	0.0	0.0	
Risk is unrelated to sex or age	42.6	61.1	
3. Which of the following professionals are considered legally responsible for unnecessary exposure to ionizing radiation and/or improperly performed radiologic exams?			0.099
Only the referring physician	4.2	0.0	
Only the radiologist	23.4	11.1	
Only the interventional radiologist (other than radiologist)	17.0	0.0	
Only the radiographer	2.1	0.0	
All of the above	**53.3**	**88.9**	
4. Which of the following professionals is most likely to be exposed to ionizing radiation because of their job?			0.277
Nuclear medicine physicians	19.2	0	
Radiographers	29.8	27.8	
Interventional cardiologist and radiologists	**48.9**	**66.7**	
Non-interventional radiologists	2.1	5.5	
Surgeons	0.0	0.0	
5. Which of the following tissues is most susceptible to ionizing radiation damage?			0.020*
Kidney	23.4	0.0	
Breast	**25.5**	**66.7**	
Bone	27.7	22.2	
Liver	21.3	5.6	
Muscle	2.1	5.5	
6. Which of the following diseases may be a result of stochastic radiation damage?			0.025*
Dermatitis	21.9	11.1	
Leukemia	**14.9**	**38.9**	
Alopecia	8.1	0.0	
Cataract	4.1	11.1	
All of the above	51.0	38.9	
7. Which of the following best describes the concept of "dose optimization"?			0.218
Prescribed and performed only when vital	6.4	0.0	
The dose must be kept as low as reasonably possible	**57.4**	**88.9**	
The scan volume should be as large as possible	10.6	0.0	
Contrast resolution is maximized to assess even the finest image details	6.4	0.0	
All of the above	19.0	11.1	

*Statistical significant at $p < 0.05$

Radiation protection knowledge

In Part 3 of the questionnaire, which dealt with the comparison radiation dose from various medical procedures, 18 (38.3%) of the 5th year medical students and 10 (55.6%) of the radiology residents knew the correct average dose from a posteroanterior chest x-ray, but only one (2.1%) of the 5th year medical students and two (11.1%) of the radiology residents knew the average radiation dose from background radiation. Ten (21.3%) of the 5th year medical students and one (5.6%) of the radiology residents correctly chose 50-100 time as the average radiation dose of the lumbar spine x-ray compare to chest x-ray. Ten to fifty time was acknowledged by 17 (36.2%) of the 5th year medical students and 7 (38.9%) of the radiology residents as the correct average dose of mammography compare to chest x-ray. The comparison dose of a chest computed tomography, about 100-500 times of a chest x-ray was recognized by 14 (29.8%) and 4 (22.2%) of the 5th year medical students and the radiology residents, respectively. Fifteen (83.3%) of the 5th year medical students and 2 (11.1%) of the radiology residents, respectively, knew the correct dose from a pelvis MRI and positron emission tomography-computed tomography (PET-CT). However, only 22 (46.8%) and 18 (38.3%) of the 5th year medical students and the radiology residents, respectively, were able to recognize the correct pelvis MRI and positron emission tomography-computed tomography (PET-CT) doses. Zero mSv, the correct abdominal ultrasound dose, was recognized by 30 (63.8%) of the 5th year medical students and 16 (88.9%) of the radiology residents. Six (12.8%) of the 5th year medical students and 1 (5.6%) of the radiology residents correctly chose more than 500 times as the correct dose from a myocardial scintigraphy (a two-day protocol with 99mTc-Sestamibi) (Table 3).

Table 3. Responses of participants related to radiation protection knowledge (part 3 of the questionnaire). Correct answers are in bold

	5th year medical students	Radiology residents	*p*-value
1. What is the average dose from a posteroanterior chest radiograph?			0.230
< 0.01 mSv	12.8	27.8	
0.01–0.1 mSv	**38.3**	**55.6**	
0.1–1 mSv	25.5	5.5	
1–10 mSv	0.0	0.0	
10–100 mSv	17.0	5.5	
> 100 mSv	4.3	5.6	
2. If a PA chest radiograph counts as 1 unit, how much is the average dose due to natural background radia-tion?			0.243
0	10.6	11.1	
1–10	36.2	55.6	
10–50	29.8	22.2	
50–100	17.0	0.0	
100–500	**2.1**	**11.1**	
>500	4.3	0.0	
3. If a PA chest radiograph counts as 1 unit, how much is the average dose from a lumbar x-ray examination?			0.493
0	2.1	0.0	
1–10	42.5	66.7	
10–50	27.7	27.8	
50–100	**21.3**	**5.5**	
100–500	6.4	0.0	
> 500	0.0	0.0	

Table 3. Responses of participants related to radiation protection knowledge (part 3 of the questionnaire). Correct answers are in bold

	5th year medical students	Radiology residents	*p*-value
4. If a PA chest radiograph counts as 1 unit, how much is the average dose due to mammography (bilateral, two projections each - four images total)?			0.137
0	0.0	0	
1–10	36.2	27.8	
10–50	**36.2**	**38.9**	
50–100	12.7	33.3	
100–500	14.9	0.0	
> 500	0.0	0.0	
5. If a PA chest radiograph counts as 1 unit, how much is the average dose from a chest CT without contrast enhancement?			0.706
0	0.0	0.0	
1–10	6.4	5.6	
10–50	27.7	33.3	
50–100	25.5	33.3	
100–500	**29.8**	**22.2**	
> 500	10.6	5.6	
6. If a PA chest radiograph counts as 1 unit, how much is the average dose due to a pelvis MRI?			0.250
0	**46.8**	**83.2**	
1–10	4.2	5.6	
10–50	17.0	5.6	
50–100	12.8	5.6	
100–500	14.9	0.0	
> 500	4.3	0.0	
7. If a PA chest radiograph counts as 1 unit, how much is the average dose from a whole-body PET-CT?			0.323
0	4.4	0.0	
1–10	2.1	16.7	
10–50 mSv	27.6	27.8	
50–100 mSv	10.6	16.7	
100–500 mSv	17.0	27.8	
> 500 mSv	**38.3**	**11.0**	
8. If a PA chest radiograph counts as 1 unit, how much is the average dose from an abdominal ultrasound ex-amination?			0.325
0	**63.8**	**88.9**	
1–10	6.4	5.6	
10–50	12.8	0.0	
50–100	10.6	5.6	
100–500	4.2	0.0	
> 500	2.1	0.0	
9. If a PA chest radiograph counts as 1 unit, how much is the average dose from myocardial scintigraphy (2 days protocol with 99mTc-Sestamibi)?			0.093
0	8.5	16.6	
1–10	21.3	50.0	
10–50	25.5	5.6	
50–100	17.0	22.2	
100–500	14.9	0.0	
> 500	**12.8**	**5.6**	

* Statistical significant at $p < 0.05$

Discussion

This study represents the first survey conducted Maharaj Nakorn Chiang Mai Hospital, Thailand focused on awareness of radiation protection and knowledge of radiological examination doses. Several types of research demonstrate that the level of knowledge of the 5th year medical students regarding ionizing radiation and the need for radiation protection is remarkably poor (5-7, 10,11).

Both the 5th year medical students and radiology residents had limited knowledge about stochastic radiation damage. That lack of knowledge could be expected to affect a doctor's ability to advise patients about the risks and benefits of a radiological test. Additionally, underestimation of the risks of imaging-related radiation could result in unnecessary exposure of patients to radiation.

Only 50% of the 5th medical students knew about the "as low as reasonably achievable" (ALARA) concept of dose optimization, while 88.9% of radiology residents knew about that concept, reflecting a gap in radiation awareness between medical students and radiology residents. That gap appears to be the result of insufficient lectures on the subject, currently consisting of a single one-hour lecture during the radiology allotment for 5th year medical students. This knowledge gap should be taken into consideration when developing the medical student curriculum in order to minimize unnecessary exposure of individual patients and the community to radiation and its accompanying risk of cancer.

This investigation also found insufficient knowledge about radiological examination doses among radiology residents. Currently, radiology resident training focuses mainly on diagnostic methods and treatments to benefit patients and pays relatively less attention to subtle long-term consequences of exposure to ionizing radiation which cause a few essential trivial effects. Techniques which could improve residents' knowledge of ionizing radiation exposure include, e.g., providing additional lectures, self-directed learning and teaching files as well as conferences on morbidity and mortality.

Finally, the comparison of radiation protection awareness and knowledge of radiological examination dosage between the 5th year medical students and radiology residents shows that radiology residents have a slightly better level of knowledge than medical students. This difference can be explained by the nature of the resident academic curriculum of radiology students which includes a greater focus on protection awareness since the students will spend the majority of their professional careers in the radiation field.

A key strength of this study is it that it represents the first research effort in Thailand to try to assess the awareness of radiation protection and knowledge of radiation dose among medical students and radiology residents. One limitation of the study is the small sample size. Studies which include a larger number of medical students and radiology residents may generate more accurate results as could extending the time allowed for completion of the survey.

Conclusions

There is evidence of inadequate awareness of radiation protection and knowledge of radiation dose among the 5th year medical students and radiology residents at Maharaj Nakorn Chiang Mai Hospital, Thailand. One potentially effective way to improve radiation protection awareness and increase knowledge of radiological examination doses among the 5th year medical students and radiology residents would be to add theoretical and practical modules on those subjects to the educational curricula.

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การตระหนักถึงการป้องกันอันตรายจากรังสี และความรู้เกี่ยวกับปริมาณรังสีที่ได้รับจากการตรวจวินิจฉัยของนักศึกษาแพทย์ชั้นปีที่ 5 และแพทย์ประจำบ้านรังสีวินิจฉัย โรงพยาบาลมหาราชนครเชียงใหม่ คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

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วัตถุประสงค์ เพื่อประเมินการตระหนักถึงการป้องกันอันตรายจากรังสี และความรู้เกี่ยวกับปริมาณรังสีที่ได้รับจากการตรวจวินิจฉัย ของนักศึกษาแพทย์ชั้นปีที่ 5 และแพทย์ประจำบ้านรังสีวินิจฉัย

วิธีการ ผู้วิจัยได้ส่งแบบสอบถามผ่านทาง Google forms ไปยังนักศึกษาแพทย์ชั้นปีที่ 5 และแพทย์ประจำบ้านรังสีวินิจฉัยที่ปฏิบัติงานในโรงพยาบาลมหาราชนครเชียงใหม่ ในระหว่างวันที่ 10-17 กรกฎาคม พ.ศ. 2562 โดยให้อาสาสมัครผู้เข้าร่วมวิจัยทำการตอบแบบสอบถามให้ครบถ้วนภายในเวลา 15 นาที

ผลการศึกษา มีอาสาสมัครเข้าร่วมตอบแบบสอบถามทั้งสิ้นจำนวน 65 คน เป็นนักศึกษาแพทย์ชั้นปีที่ 5 จำนวน 47 คน และแพทย์ประจำบ้านรังสีวินิจฉัย จำนวน 18 คน จากการตอบแบบสอบถามพบว่า ร้อยละ 48.9 ของนักศึกแพทย์ชั้นปีที่ 5 และร้อยละ 61.1 ของแพทย์ประจำบ้านรังสีวินิจฉัย ประเมินตนเองว่ามีความรู้เกี่ยวกับอันตรายจากรังสีและปริมาณรังสีที่ได้รับจากการตรวจวินิจฉัยอยู่ในเกณฑ์ที่เหมาะสมและเพียงพอ เมื่อประเมินความรู้โดยการทำแบบทดสอบพบว่านักศึกษาแพทย์ชั้นปีที่ 5 ทำคะแนนได้ 6.2 คะแนน ส่วนแพทย์ประจำบ้านรังสีวินิจฉัย ทำได้คะรแนน 7.9 คะแนน จากคะแนนเต็ม 16 มีเพียงร้อยละ 14.9 ของนักศึกษาแพทย์ชั้นปีที่ 5 และ ร้อยละ 38.9 ของแพทย์ประจำบ้านรังสีวินิจฉัยที่มีความรู้เกี่ยวกับ stochastic radiation damage อย่างไรก็ตามร้อยละ 57.4 ของนักศึกษาแพทย์ชั้นปีที่ 5 และร้อยละ 88.9 ส่วนแพทย์ประจำบ้านรังสีวินิจฉัยมีความรู้เกี่ยวกับ “as low as reasonably achievable” (ALARA) concept นักศึกษาแพทย์ร้อยละ 50 ไม่มีความรู้ว่า MRI และ ultrasound ไม่ได้มีปริมารณรังสี

สรุป นักศึกษาแพทย์ชั้นปีที่ 5 และแพทย์ประจำบ้านรังสีวินิจฉัย ที่ปฏิบัติงานในโรงพยาบาลมหาราชนครเชียงใหม่ยังมีความรู้เกี่ยวกับอันตรายจากรังสีและปริมาณรังสีที่ได้รับจากการตรวจวินิจฉัยอยู่ในเกณฑ์ที่ไม่เพียงพอ ดังนั้นเพื่อการพัฒนา จำเป็นต้องเพิ่มการเรียนการสอนทั้งทางภาคทฤษฎีและภาคปฏิบัติเข้าไปในหลักสูตรการเรียนการสอน **เชียงใหม่เวชสาร 2563; 59(4):197-205.**

คำสำคัญ: ภาพเอกเรย์ทรวงอก นักศึกษาแพทย์ ปริมาณรังสี การป้องกันอันตรายจากรังสี