Medical student's knowledge of ionizing radiation and radiation protection

Sarah K. Hagi, MSc BME, PhD, *Mawya A. Khafaji,* PhD, PGCME.

ABSTRACT

الأهداف : تقييم مدى إدراك طلاب وطالبات السنة الرابعة بكلية الطب لخصائص الإشعاع المؤين وطرق الحماية منها، ودراسة مدى فعالية المحاضرات التي تعمل على تصحيح المفاهيم الخاطئة.

الطريقة : أُجريت هذه الدراسة الاستعراضية في جامعة الملك عبدالعزيز، جدة، المملكة العربية السعودية واستمرت خلال الفترة من ديسمبر 2009م إلى فبراير 2010م. لقد تم تصميم استبيان مكون من 7 أسئلة متعددة الخيارات، وبعد ذلك تم توزيعه على طلبة كلية الطب قبل وبعد المحاضرة من أجل تقييم مستوى المعرفة لديهم. أُلقيت هذه المحاضرة التي استمرت لمدة 3 ساعات على حوالي 333 طالباً (72%) من أصل 459 طالباً، وقد تضمنت المحاضرة المواضيع المتعلقة بالإشعاع المؤين وطرق الحماية منه، وفيما بعد قام 6 أطباء ملمين بالمنهج بالتأكد من مدى صحة ومصداقية أوراق الاستبيان، بالإضافة إلى تحليل أجوبة الطلاب.

النتائج : شملت هذه الدراسة 253 (76%) طالباً من الذين أكملوا بيانات الاستبيان قبل وبعد إلقاء المحاضرة وذلك من أصل 333 طالباً ممن حضروا المحاضرة. وأشارت نتائج الدراسة بأن معدل الدرجات الصحيحة للطلبة قد ارتفع من 47% قبل المحاضرة إلى 78% بعد المحاضرة، أي بواقع تحسن في المعرفة المكتسبة يصل إلى 31% (*p*=0.01).

الخاتمة : أظهرت النتائج أن إدراك طلبة السنة الرابعة لخصائص الإشعاع المؤين وطرق الحماية منه غير كافي، وأن تقديم المحاضرات اللازمة حول هذا الموضوع قد قام بتحسين معرفتهم وتصحيح مفاهيمهم الخاطئة. وهكذا فقد أثبتت هذه الدراسة أن باستطاعة الطلبة تعلم واستيعاب المفاهيم العامة المُتعلقة بالإشعاع المؤين وذلك من خلال محاضرة واحدة.

Objectives: To assess the knowledge of fourth-year medical students in ionizing radiation, and to study the effect of a 3-hour lecture in correcting their misconceptions.

Methods: A cohort study was conducted on fourth-year medical students at King Abdul-Aziz University, Jeddah, Kingdom of Saudi Arabia during the academic year 2009-2010. A 7-question multiple choice test-type questionnaire administered before, and after a 3-hour didactic lecture was used to assess their knowledge. The data was collected from December 2009 to February 2010. The lecture was given to 333 (72%) participants, out of the total of 459 fourth-year medical students. It covered topics in ionizing radiation and radiation protection. The questionnaire was validated and analyzed by 6 content experts.

Results: Of the 333 who attended the lecture, only 253 (76%) students completed the pre- and post questionnaire, and were included in this study. The average student score improved from 47-78% representing a gain of 31% in knowledge (*p*=0.01).

Conclusion: The results indicated that the fourth-year medical student's knowledge regarding ionizing radiation and radiation protection is inadequate. Additional lectures in radiation protection significantly improved their knowledge of the topic, and correct their current misunderstanding. This study has shown that even with one dedicated lecture, students can learn, and absorb general principles regarding ionizing radiation.

Saudi Med J 2011; Vol. 32 (5):

From the Department of Radiology, Faculty of Medicine, King Abdul-Aziz University, Jeddah, Kingdom of Saudi Arabia.

Received 3rd November 2010. Accepted 21st February 2011.

Address correspondence and reprint request to: Dr. Sarah Hagi, Department of Radiology, Faculty of Medicine, King Abdul-Aziz University, PO Box 80215, Jeddah 21589, Kingdom of Saudi Arabia. Tel. +966 (2) 6401000 Ext. 17365. Fax +966 (2) 6408149. E-mail: SarahHagi@gmail.com

Radiological investigations have been widely used in patient management, and these investigations involve exposing the patients to either ionizing, or non-ionizing radiation. The number of investigations involving ionizing radiation has dramatically increased in the past decade. It is estimated that CT examinations have increase in the USA by a factor of 10 from 1980-2005.[1] In the USA, CT examinations account for 13% of all diagnostic exposure, but "is estimated to be responsible for more than 70% of the collective radiation dose delivered to patients".[2] Advancement in technology has led to complex interventional radiological procedures and nuclear medicine investigations. With these advancements, concerns regarding radiation dose to patients arise. Although most of these exposures are justified, not all of them are clinically useful. Today, patients are more aware that radiation can be harmful. During medical exposure from examinations involving radiation, doctors are the main source of information. They have to be prepared and aware of the risks, benefits, and dose in order to provide an accurate explanation to their patients. Doctor's justification of diagnostic imaging requests depend on their experience and knowledge of radiation doses of these investigations. This has been of concern among faculty members in charge of undergraduate medical students, since this knowledge should already be developed at the undergraduate level.[3-5] Since 1989 and up to present, several studies were questioning medical students' knowledge related to ionizing radiation, and more research has been conducted on the topic. Some of them found that students' knowledge of radiation safety is insufficient, and hundreds of unnecessary examinations are performed every year due to this lack of knowledge. They have emphasized that radiation protection should be mandatory and part of the medical school curriculum.[3-10]

All these disappointing results urged O'Sullivan et al[11] to investigate the effect of a curriculum in clinical radiology that included radiation protection. They assessed the awareness of all medical students (from years 1-5) of radiation exposure, and studied the effect of clinical radiology curriculum on their knowledge. They used a questionnaire that assessed radiation knowledge and radiology teaching. First year medical student on their first week of classes was used as a control group. Improvement in knowledge was found year after year in comparison with the control group. They concluded that "those who received radiology teaching" (87%) performed better than those who did not. But still, only 60% of the population knew that CT used ionizing radiation, and approximately 25% still believed that magnetic resonance imaging (MRI) used ionizing radiation. They concluded that "all medical schools should implement radiation protection instruction as part of the undergraduate medical curriculum".[11] The aim of the present study is to assess the knowledge of medical students at King Abdul-Aziz University (KAU) in Jeddah, Kingdom of Saudi Arabia (KSA) in ionizing radiation, and to study the effect of a 3-hour lecture as part of their radiology module on that knowledge.

Methods. ***Lecture.*** The undergraduate medical students during their fourth year at KAU (first year of clinical teaching) are exposed to a 30-hour medical imaging module. Part of this module is dedicated to principles of ionizing radiation, and radiation protection. A 3-hour lecture covering materials on diagnostic procedures that use ionizing and non-ionizing radiation, as well as radiation protection principles was given from December 2009 to February 2010 to male and female students of KAU, Jeddah, KSA. The outline of this lecture is shown in **Table 1**.

Questionnaire. A modified version of a previously published questionnaire[4] in the format of a multiple choice test was used to assess the knowledge of medical students (**Table 2**). It tested the students' knowledge regarding diagnostic procedures, such as CT and MRI. In addition, it included questions on radiation protection and basic principles of ionizing radiation. The validity of this questionnaire was confirmed by 6 radiologists, and reliability was determined by Cronbach alpha (0.83). These content experts (who teach and train medical students during their clinical rotations) rated the importance of each of the 7 questions to the core knowledge required before graduation. They all agreed that questions 1, 2, and 4 are core knowledge, and the fourth-year medical students must know the answer for them to move on to the next year. In addition, 5 of the content expert thought that questions 3, 6, and 7 are core knowledge, however, only 2 of them felt that knowing the international standard (SI) unit for measuring radioactivity is important at this stage.

Subjects. The cohort consisted of fourth-year undergraduate medical students at KAU who attended the lecture. The questionnaire was administered before and after the lecture. Two questionnaires were collected for each student. Students who did not provide both pre- and post completed questionnaires were excluded from the study. The approval was obtained from the Local Ethics Committee at KAU to conduct the study.

Data was entered and analyzed using the Statistical Package for Social Sciences version 19 (SPSS Inc, Chicago, IL, USA). Pearson correlation coefficient was carried out to study correlation between variables. $P<0.05$ was considered significant.

Results. Out of the 459 fourth-year medical students at KAU in 2010, 333 (72%) attended the-3 hour lecture. Of those, 253 (76%) participated in the post-lecture test, and represented the study population. Among these students, 126 (49.8%) were female, and 127 (50.2%) were male. Two questionnaires were collected for each participant, that is, pre- and post lecture. Correct answers were given one mark each, while the incorrect ones, or omissions received a mark of zero. A total score was given to each student before, and after the lecture. **Table 2** shows the 253 students answers on the 7 questions, pre- and post lecture. Improvement in test score was found in all questions, except question 2, "Intravenous contrast material used in angiogram is radioactive". This was not one of the topics covered in the lecture due to lack of time. We assume that the students' first answer to this question was a presumption, and the second represents what they really know about it (only 26% knew the correct answer). The average test score improvement was calculated from subtracting pre-lecture score from post-lecture score for each question. Since content facts for the second question was not covered in the lecture, test score improvement for that question could not be measured. Therefore, question 2 was excluded from this analysis. Improvement in all other questions was represented by higher post-test score that varied between 19-83%. For the entire study, the average

Table 1 - Outline of the lecture.

No of slides for each topic	Topic
1-5	Types of radiation, and difference between ionizing and non-ionizing radiation
6-9	Interaction of radiation with matter
10-14	Radioactivity and half-life
15-28	Radiological diagnostic procedures that use ionizing radiation
29-34	Awareness of the level of radiation that patients are exposed to during radiological investigation
35-52w	Radiation protection principles
53-54	Radiosensitivity
55-60	Risk associated with each type of investigation
60-68	Image quality versus dose
69-80	Personal monitoring device for radiation safety
81-91	Shielding and monitoring equipment
92-96	Role of a medical physicist in diagnostic and therapeutic radiology

Table 2 - Students response to the 7 questions pre- and post lecture.

Questions	Pre	Post	*P*-value
	n (%)		
Q1			0.000
Incorrect	99 (39.0)	34 (13.0)	
Correct	154 (61.0)	219 (87.0)	
Q2			
Incorrect	162 (64.0)	188 (74.0)	NA*
Correct	91 (36.0)	65 (26.0)	
Q3			
Incorrect	106 (42.0)	16 (6.0)	0.003
Correct	147 (58.0)	237 (94.0)	
Q4			
Incorrect	72 (29.0)	24 (10.0)	0.028
Correct	181 (71.0)	229 (90.0)	
Q5			
Incorrect	223 (88.0)	13 (5.0)	0.000
Correct	30 (12.0)	240 (95.0)	
Q6			
Incorrect	133 (53.0)	43 (17.0)	0.001
Correct	120 (47.0)	210 (83.0)	
Q7			0.000
Incorrect	145 (57.0)	76 (30.0)	
Correct	108 (43.0)	177 (70.0)	

NA - not applicable because incorrect answers of the post-lecture test were more than those in the pre-lecture test

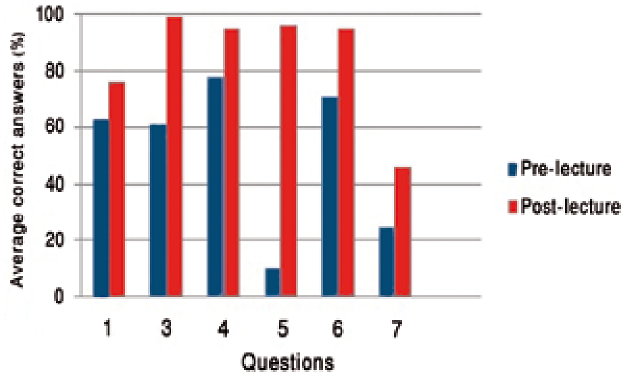

Figure 1 - Data represents the average percentages of correct answers for question 1, 3, 4, 5, 6, and 7, pre- and post lecture for male students.

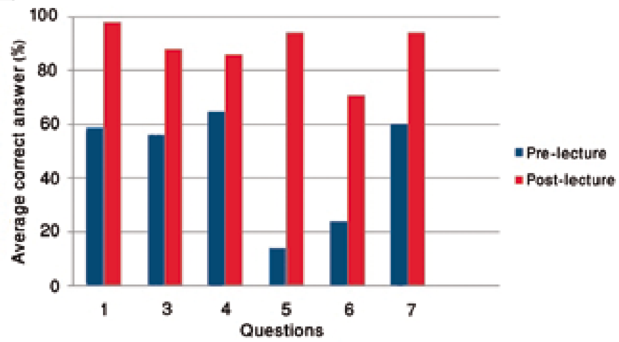

Figure 2 - Data represents the average percentages of correct answers for question 1, 3, 4, 5, 6, and 7, pre- and post lecture for female students.

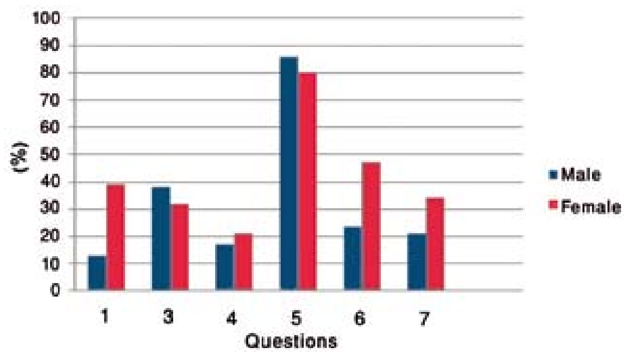

Figure 3 - Data represents the average percentages of test score improvement for question 1, 3, 4, 5, 6, and 7 for female and male students.

student score improved from 47-78%, representing a gain in knowledge of 31% (p=0.01). The results above suggests a highly significant effect of the 3-hour lecture in correcting the misconceptions of students prior to the lecture. On the pre-lecture questionnaire, only 44 (17%) students scored above 60%, that is the passing grade. Among those students, only 6 (3%) scored 86, which was the highest score. Four students got a zero on the pre-test. Furthermore, 40% of the students thought that objects in the room would still emit radiation after completion of exposure. The dose from CT procedures was under-estimated by 30% of the students. In addition, only 47% of the students knew that MRI does not involve ionizing radiation. On the post-test, 219 (87%) students scored above the passing grade. Among these, 23 students scored a full mark of 100. Only 3 students (30%) scored the lowest grade on the post-test. When comparing the before lecture knowledge of female to male students, the average score was 43% for female, and 51% for male. **Figures 1 & 2** show the improvement in test scores for both male and female, which was significant (p=0.028). The average test score improvement was 35% for females, and 26.6% for males. Improvement in the test scores was documented for female students in questions 1, 4, 6, and 7, higher than that of the male students. On the other hand, improvement for male students in questions 3, and 5 were higher than that for female students (**Figure 3**). The results suggest that female students benefited slightly more from the 3-hour lecture. Also, the pre-lecture knowledge of male students was higher than that of female students on questions 1, 3, 4, and 6.

Discussion. The use of x-ray in diagnostic radiology requires good practice, as well as proper knowledge of dose associated with all types of procedures. The International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) established guidelines for the safe application of all types of radiological procedures and personnel safety. Extensive literature review revealed that there is a worldwide concern regarding how much doctors know on this topic. Several publications proved that the knowledge of medical students on ionizing radiation and radiation protection is very poor.[4,6-11]

It was reported that interns have avoided accompanying patients in need of medical support during radiological examinations, furthermore pregnant female interns worried of their well-being, have avoided walking through the radiology department. In addition, some medical students avoid standing in the control console area during a radiological exposure worried of the dose in that area.[9] All this is a reflection of knowledge deficiency among future doctors. This study demonstrated that medical students have a shortage of knowledge with regard to ionizing radiation, diagnostic imaging, and radiation safety. Thus, these deficiencies should be taken into consideration when designing undergraduate curriculum to meet the SI and future challenges. Findings from the present study agrees with those by Mubeen et al,[4] which showed that approximately 40% of their student population believed that objects in the x-ray room emit radiation after an x-ray procedure. Their study showed that 18% of the students thought that MRI involves ionizing radiation. The present investigation at KAU, documented that nearly 50% of the students thought that MRI involves ionizing radiation, and 28% underestimated the dose from CT scan. In addition 60% of them were not sure of the radiosensitivity of the human body organ with regard to radiation.

Differences in knowledge level among genders were reported in 2007 by Arslanoglu et al.[8] They have found that female students had slightly lower knowledge with regard to ionizing radiation demonstrated in their overall score of 42%, while male students scored 57%. Similarly, the conducted study confirmed that female students scored 43%, while male students 51% on the pre-lecture questionnaire. The slightly lower score reported for female students shifted on the post-lecture questionnaire to show improvement in knowledge (35%) compared to 26% for male students. However, these differences were not statistically significant. Both female and male students' knowledge improved in all questions with the exception of question number 2.

The findings of the present study re-enforces the importance of adjustments to medical students curriculum, and emphasizes that "radiation protection should be taught as a priority" to improve future clinicians' knowledge.[10]

A weakness of this study was that the intended topics related to the questionnaire could not be fully covered within 3 hours. Therefore, it was recommended to the module coordinator at KAU to increase the teaching time to 6 hours (that is, 2 lectures), and approval was granted for the next academic year. Time between the lecture and the post questionnaire was intended to be as close as possible to assess only the lecture effect. The whole module including the clinical rotation in radiology could have an impact on students' knowledge, and can be measured 4-weeks later using a third questionnaire administered after the completion of imaging module.

In conclusion, it has been documented that medical students worldwide have a shortage of knowledge with regard to ionizing radiation, diagnostic imaging, and radiation safety. Therefore, this gap in knowledge should be taken into consideration when designing undergraduate curriculum. The findings from the present study emphasizes that radiation protection should be taught as a priority to improve future clinician's knowledge.

This study provided evidence that additional lecture in radiation protection and ionizing radiation significantly improved medical students' knowledge of the topic. Consequently, this will result in improving health service quality by minimizing patient exposure dose and providing proper patient education. Further investigation is required to determine the optimum method of improving medical students and current referring doctors' knowledge of radiation protection.

References

1. McCusker MW, de Blacam C, Keogan M, McDermott R, Beddy P. Survey of medical students and junior house doctors on the effects of medical radiation: is medical education deficient? ***Ir J Med Sci*** 2009; 178: 479-483.
2. Lee CI, Haims AH, Monico EP, Brink JA, Forman HP. Diagnostic CT scans: assessment of patient, physician, and radiologist awareness of radiation dose and possible risks. ***Radiology*** 2004; 231: 393-398.
3. Mubeen SM, Abbas Q, Nisar N. Knowledge about ionising and non-ionising radiation among medical students. ***J Ayub Med Coll Abottabad*** 2008; 20: 118-121.
4. Singh RK, McCoubrie P, Burney K, Miles JA. Teaching medical students about radiation protection-what do they need to know? ***Clin Radiol*** 2008; 63: 1344-1349.
5. Shiralkar S, Rennie A, Snow M, Galland RB, Lewis MH, Gower-Thomas K. Doctors' knowledge of radiation exposure: questionnaire study. ***BMJ*** 2003; 327: 371-372.
6. Burney K, Miles JA. A study of the awareness of radiation doses of radiological investigations amongst clinicians. BJR Congress series. In: Proceedings of the United Kingdom Radiological Congress (UKRC); 2005 June 8. Manchester, UK. p. 89. [updated 2011 March 11; accessed 2011 March 14]. Available from URL: http://www.ukrc.org.uk/
7. Jacob K, Vivian G, Steel JR. X-ray dose training: are we exposed to enough? ***Clin Radiol*** 2004; 59: 928-934.
8. Arslanoglu A, Bilgin S, Kubal Z, Ceyhan MN, Ilhan MN, Maral I. Doctors' and intern doctors' knowledge about patients' ionizing radiation exposure doses during common radiological examinations. ***Diagn Interv Radiol*** 2007; 13: 53-55.
9. Tavakoli MR, Seilanian TF, Saadatjou SA. Knowledge of medical students on hazards of ionizing radiation. ***Journal of Medical Education*** 2003; 3: 3-6.
10. Gorse SJ. Doctors' knowledge of exposure to ionizing radiation: radiation protection should be taught as a priority. ***BMJ*** 2003; 327: 1166.
11. O'Sullivan J, O'Conner OJ, O'Regan K, Clarke B, Burgoyne LN, Ryan MF, et al. An assessment of medical students' awareness of radiation exposures associated with diagnostic imaging investigations. ***Insights into Imaging*** [updated 03 March 2010. accessed 12 May 2010] Available from URL: http://i3-journal.org/html/img/pool/awareness_fulltext.pdf

Appendix

By completing this questionnaire and submitting it to your professors, you are agreeing to participate in a study that will tell us a lot about missing information in your learning path to become better doctors

Year:

Computer No.:

Ionizing Radiation in Diagnostic Imaging Questionnaire

Number	Questions			
1	After completion of an x-ray examination, objects in the room emits radiation			
	a) true		b) false	
2	Intravenous contrast material used in angiogram is radioactive			
	a) true		b) false	
3	Which of the following organs is more important to be protected against radiation in head and neck radiography			
	a) Esophagus	b) Skin tissue	c) Spinal cord and brain	d) Thyroid gland
4	Which of the following procedures is associated with greater dose of radiation			
	a) Barium enema	b) CT scan	c) Chest x-ray	d) Skull x-ray
5	The SI unit for measuring radioactivity is:			
	a) Sv	b) Rad	c) Gy	d) Bq
6	An MRI of the spine of 45 minutes length is equivalent to:			
	a) 25 chest x-rays	b) 15 chest x-rays	c) 5 chest x-rays	d) 0 chest x-ray
7	Gamma ray is more hazardous than x-ray			
	a) true		b) false	

Thank you for participating.

Medical Physics Unit
Radiology Department, KAUH