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Assessment of the application level of radiation protection and awareness of radiation safety regulations among the radiographers at Yogyakarta Special Region, Indonesia

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ABSTRACT

A strong relation between cancers and radiation exposure has been reported. Radiation may damage DNA in the cell. Therefore, radiation protection program must be applied in the radiology department. Morover, the radiographer should have high level of awareness and risk assessment for radiation. Personal radiation monitoring is one of the main radiation protection, especially for pregnant worker and her fetus. This study was conducted to evaluate the application, awareness and risk assessment levels of radiation protection among radiographers at hospitals in Yogyakarta Special Region, Indonesia. This was a descriptive study, applying a cross sectional survey at hospitals in Yogyakarta. The subjects were radiographers of both governmental and private hospitals. There were 101 respondents from a total of 124 radiographers. The data obtained were tabulated and analyzed using Chi Square test. The study revealed that 69.3% of the respondents had low application level of radiation protection, 19.8% did not know the meaning of ALARA (As Low As Reasonably Achievable), 50.5% were not aware of Inverse Square Law. The study also reported that 36.6% of the respondents did not know the amount of radiation that entered their body last year, 61.4% of radiographers thought that the risk assessment of radiation was not enough, 18.8% of radiographers were never use any radiation monitoring device, and 90.1% stated that there was no additional protection or radiation monitoring to the pregnant radiographer. However, there were no significant differences between duration of working, type of imaging modality, academic level, and training course for radiation protection. In conclusion, there was no difference in the application, awareness, and risk assessment levels of radiation protection among the radiographers at hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection. In addition, the application, awareness, and risk assessment levels of radiation protection were not sufficient.

Key words: radiation protection – ALARA – radiographer – hospital – risk assessment

ABSTRAK

Hubungan yang kuat antara kejadian kanker dan pajanan sinar radiasi telah dilaporkan. Radiasi dapat menyebabkan kerusakan DNA dalam sel. Oleh karena itu program perlindungan radiasi harus dijalankan di bagian radiologi. Selain itu radiografer harus mempunyai perhatian dan penilaian risiko yang tinggi. Pemantauan radiasi individu merupakan salah perlindungan radiasi utama khususnya pekerja yang hamil dan bayi yang dikandungnya. Penelitian ini dilakukan untuk mengevaluasi pelaksanaan, perhatian dan tingkat penilaian risiko perlindungan radiasi diantara radiografer pada rumah sakit di Daerah Istimewa Yogyakarta (DIY), Indonesia. Penelitian ini merupakan penelitian diskriptif melalui survei potong lintang pada rumah sakit di DIY dengan subjek penelitian adalah radiografer baik dari rumah sakit pemerintah maupun swasta. Sebanyak 101 responden dari total 124 radiografer berpartisipasi dalam penelitian. Data yang diperoleh ditabulasi dan dianalisis menggunakan uji Chi Square. Hasil penelitian menunjukkan 69,3% reponden mempunyai tingkat pelaksanaan rendah dalam perlindungan radiasi, 19,8% tidak tahu makna ALARA, 50,5% hukum balikan kuadrat. Dari penelitian ini juga dilaporkan 36,6% responden tidak tahu jumlah radiasi yang mengenai tubuhnya dalam satu tahun terakhir, 61,4% radiografer beranggapan bahwa penilaian risiko radiasi tidak cukup, 18,8% radiografer tidak pernah menggunakan peralatan pemantauan radiasi apapun, dan 90,1% menyatakan bahwa tidak ada perlindungan tambahan apapun atau pemantauan radiasi terhadap radiografer yang hamil. Namun

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demikian, tidak terdapat perbedaan antara masa kerja, tipe modalitas pencitraan, tingkat pendidikan, dan pelatihan perlindungan radiasi. Dapat disimpulkan, tidak terdapat perbedaan dalam hal pelaksanaan, perhatian, tingkat penilaian risiko perlindungan radiasi diantara radiografer pada rumah sakit di DIY antara masa kerja, jenis modalitas pencitraan, tingkat pendidikan, dan pelatihan perlindugnan radiasi. Selain itu, pelaksanaan, perhatian dan tingkat penilaian risiko perlindungan radiasi dianggap tidak memadai.

Kata kunci: pelindung radiasi – ALARA – radiografer – rumah sakit – penilaian risiko

INTRODUCTION

The average annual radiation dose received by general public is 2.5mSv, and 15% of them are related to medical exposures.[1,2] The use of radiation in medical practices has evolved since its beginning and 30-50% of medical decisions are based on radiological examinations.[3] However, the hazards of ionizing radiation are irrefutable. For instance, according to recent studies in United Kingdom, 100-250 death per year occurs because of harmful effects of medical radiation exposures.[1,4] Reducing radiographer and patients radiation dose exposure through As Low As Reasonably Achievable (ALARA) is based on the recommendations of all radiation protection organizations such as International Commission on Radiological Protection (ICRP) and National Radiological Protection Board (NRPB).[1-4]

Awareness of medical practitioners on hazards of ionizing radiation has been reported to be one of the main factors for decreasing the radiographer's and radiologist's dose in medical practices.[2,4] These studies indicated that the improvement of information about radiation dose received in different diagnostic imaging procedures to radiographers and radiologist is important. The hazards of radiation exposure, therefore, help them to optimize the radiations protections during different medical imaging scanning. The first step of radiation protection can be obtained by conducting radiological investigations.[4,5] If radiographers and radiologists are aware of radiation dose received in different radiological investigations, they will avoid unnecessary examinations and performs counterpart examinations with low or without radiation risk.[4-6] It seems important to instruct doctors and radiographers to give special consideration about radiation dose delivered in different imaging modalities.

MATERIALS AND METHODS

This was a descriptive study, applying a cross sectional survey. Radiographers were asked to give their responses on a number of questions related to the radiation protection among them. This study was carried out at hospitals in Yogyakarta Special Region, Indonesia during April 2011.

The studied population was all radiographers who worked in hospitals in Yogyakarta Special Region. Since the total numbers of radiographers in hospitals in Yogyakarta Special Region was small, most of them were included in the study, and therefore sampling was not performed. Data were collected from the studied population, which were a total of 124 radiographers from hospital in Yogyakarta Special Region. Data analysis was performed using a computer software package, which included univariate analysis, bivariate analysis and multivariate analysis. The protocol of the study has been approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, Gadjah Mada University, Yogyakarta.

RESULTS

Characteristics of respondents

The data were collected from 101 radiographers in 13 hospitals in Yogyakarta Special Region and surrounding areas, including governmental and private hospitals from different hospital classes. The age of respondents ranged from 22-61 years old. TABLE 1 showed the distribution of respondents according to gender, duration of working, hospital type, hospital class, and type of modality.

TABLE 1. The distribution of respondents according to gender, duration of working, hospital type, hospital class, and type of modality

No.	Item	Characteristic of respondents	Number (%)
1.	Gender	Male	54 (53.5)
		Female	47 (46.5)
2.	Duration of working	<5 Yrs	19 (18.8)
		5-9 Yrs	22 (21.8)
		10-14 Yrs	25 (24.8)
		>15 Yrs	35 (34.7)
3.	Hospital type	Governmental	64 (63.4)
		Private	37 (36.6)
4.	Hospital class	A	32 (31.7)
		B	44 (43.6)
		C	25 (24.8)
5.	Type of modality	Static radiation	98 (97.0)
		Dynamic radiation	57 (56.4)
		Radioactive material	4 (4.0)
		No radiation	26 (25.7)

***Note**: all the values were valid; static radiation includes conventional X ray, CT scan and radiotherapy; dynamic radiation includes fluoroscopy and cath. Lab.; radioactive material includes nuclear medicine; no radiation includes MRI and ultrasonography*

The hospitals were divided into three classes. Class A which provides all basic and specialty medical services with the minimal capacity about 400 beds. Class B which provides basic and some specialty medical services with minimal capacity about 200 beds, and class C which provides basic medical services with minimal capacity about 100 beds. Basic medical services include internal medicine, surgery, pediatrics and gynecology.

Application level of radiation protection

TABLE 2 showed the application level of radiation protection related to the duration of working, type of medical imaging modality, academic level, and training on radiation protection. The rate of radiographers who did not apply the required level of radiation protection was 69.3% while 30.7% of the radiographers did not apply radiation protection. There was no protection difference between the duration of working, type of imaging modality, academic level, training course for radiation protection and application level of radiation protection.

The levels of radiation protection was divided into two. Firstly, high level which means that the radiographer answered correctly on 50% or more (median) of the questions related to the application of radiation protection. Secondly, low level means that the radiographer answered correctly on less than 50% of the questions related to the application of radiation protection.

TABLE 2. Application level of radiation protection in relation to the duration of working, type of imaging modality, academic level and training course for radiation protection.

No	Item		Levels of Radiation Protection		Number (%)	p
			Low N (%)	High N (%)		
1.	Duration of working (years)		70 (69.3)	31 (30.7)		0.534
		< 10	27 (26.7)	14 (13.9)	41 (40.6)	
		>10	43 (42.6)	17 (16.8)	60 (59.4)	
2.	Imaging modality		70 (69.3)	31 (30.7)		
	Static radiation	Yes	69 (68.3)	29 (28.7)	98 (97.0)	0.170
		No	1 (1.0)	2 (2.0)	3 (3.0)	
	Dynamic radiation	Yes	41 (40.6)	16 (15.8)	57 (56.4)	0.515
		No	29 (28.7)	15 (14.9)	44 (43.6)	
	Nuclear medicine	Yes	2 (2.0)	2 (2.0)	4 (4.0)	0.393
		No	68 (67.3)	29 (28.7)	97 (96.0)	
	No radiation	Yes	18 (17.8)	8 (7.9)	26 (25.7)	0.992
		No	52 (51.5)	23 (22.8)	75 (75.3)	
3.	Academic level		70 (69.3)	31 (30.7)		0.595
		High school	5 (5.0)	1 (1.0)	6 (5.9)	
		Diploma	61 (60.4)	27 (26.7)	88 (87.1)	
		Bachelor & Master	4 (4.0)	3 (3.0)	7 (6.9)	
4.	Training course		70 (69.3)	31 (30.7)		0.397
		PPR	19 (18.8)	11 (10.9)	30 (29.7)	
		Never	51 (50.5)	20 (19.8)	71 (70.3)	

Awareness level of radiation protection

TABLE 3 showed the understanding of ALARA concept related to the duration of working, type of medical imaging modality, academic level, and training on radiation protection. The rate of radiographers who know the ALARA concept was 80.2% while 19.8% of the radiographers did not understand of ALARA concept. There was no difference between duration of working, type of imaging modalities, academic level, training courses for radiation protection and awareness level of radiation protection.

TABLE 3. Understanding ALARA concept in relation to duration of working, type of imaging modality, academic level and training course for radiation protection

No	Item		Understanding of ALARA		Number (%)	p
			Yes N (%)	No N (%)		
1.	Years of working (years)		77 (80.2)	19 (19.8)		0.329
		10	31 (32.3)	10 (10.4)	41 (42.7)	
		>10	46 (47.9)	9 (9.4)	55 (57.3)	
2.	Imaging modality		77 (80.2)	19 (19.8)		
	Static radiation	Yes	76 (79.2)	19 (19.8)	95 (99.0)	0.618
		No	1 (1.0)	0 (0.0)	1 (1.0)	
	Dynamic radiation	Yes	47 (49.0)	8 (8.3)	55 (57.3)	0.135
		No	30 (31.3)	11 (11.5)	41 (42.7)	
	Nuclear medicine	Yes	0 (0.0)	2 (2.1)	2 (2.1)	0.004
		No	77 (80.2)	17 (17.7)	94 (97.9)	
	No radiation	Yes	24 (25.0)	2 (2.1)	26 (27.1)	0.070
		No	53 (55.2)	17 (17.7)	70 (72.9)	
3.	Academic level		77 (80.2)	19 (19.8)		0.299
		High school	2 (2.1)	2 (2.1)	4 (4.2)	
		Diploma	70 (72.9)	16 (16.7)	86 (89.6)	
		Bachelor & Master	5 (5.2)	1 (1.0)	6 (6.3)	
4.	Training course		77 (80.2)	19 (19.8)		0.972
		PPR	24 (25.0)	6 (6.3)	30 (31.3)	
		Never	53 (55.2)	13 (13.5)	66 (68.8)	

TABLE 4 showed the frequency of some answers related to the application and awareness levels of radiation protection, such the use of badge film which showed that only 33 (32.7%) of the radiographers who always used it during their working. Moreover, there were 37 (36.6%) respondents who did not know the amount of radiation exposured on their bodies during last year. There was no difference between duration of working, type of imaging modalities, academic level, training courses for radiation protection and understanding of the ALARA concept.

TABLE 4. Frequency table of some answers which in relation to the application and awareness levels of radiation protection

Item	Answer	Number (%)	Missing
Understanding of ALARA concept	Yes	77 (80.2)	0
	No	19 (19.8)	
Applying ALARA concept	Yes	65 (64.4)	3
	No	33 (32.7)	
If RSO visiting the department	Yes	85 (84.2)	0
	No	16 (15.8)	
Radiation amount for radiographer during last year	<5 rem	57 (56.4)	0
	5 rem	4 (4.0)	
	>5 rem	3 (3.0)	
	Don't know	37 (36.6)	
If radiographer have badge film	Yes	87 (86.1)	0
	No	14 (13.9)	
If the radiographer use badge film	Never	19 (18.8)	0
	Rarely	28 (27.7)	
	Sometimes	3 (3.0)	
	Mostly	18 (17.8)	
	Always	33 (32.7)	
Instructions for pregnant worker	Yes	58 (57.4)	0
	No	43 (42.6)	
Demonstrating embryo dose (<50 mrem)	Yes	10 (9.9)	0
	No	91 (90.1)	

Risk assessment level of radiation protection

TABLE 5 showed the risk assessment level of radiation protection in relation to the years of working, type of medical imaging modality, academic level, and training on radiation protection. TABLE 5 also showed that there were 61.4% of radiographers who thought that there was inadequate risk assessment of radiation among them. There was no difference between duration of working, type of imaging modalities, academic level, training courses for radiation protection and risk assessment level of radiation protection.

TABLE 5. Risk assessment level of radiation protection in relation to duration of working, type of imaging modality, academic level and training course for radiation protection

No	Item		Risk assessment level		Number (%)	p
			Low N (%)	High N (%)		
1.	Years of working (years)		62 (61.4)	39 (38.6)		0.446
		< 10	27 (26.7)	14 (13.9)	41 (40.6)	
		>10	35 (34.7)	25 (24.8)	60 (59.4)	
2.	Imaging modality		62 (61.4)	39 (38.6)		
	Static radiation	Yes	59 (58.4)	39 (38.6)	98 (97.0)	0.163
		No	3 (3.0)	0 (0.0)	3 (3.0)	
	Dynamic radiation	Yes	34 (33.7)	23 (22.8)	57 (56.4)	0.683
		No	28 (27.7)	16 (15.8)	44 (43.6)	
	Nuclear medicine	Yes	4 (4.0)	0 (0.0)	4 (4.0)	0.106
		No	58 (57.4)	39 (38.6)	97 (96.0)	
	No radiation	Yes	15 (14.9)	11 (10.9)	26 (25.7)	0.653
		No	47 (46.5)	28 (27.7)	75 (74.3)	
3.	Academic level		62 (61.4)	39 (38.6)		0.089
		High school	6 (5.9)	0 (0.0)	6 (5.9)	
		Diploma	53 (52.5)	35 (34.7)	88 (87.1)	
		Bachelor & Master	3 (3.0)	4 (4.0)	7 (6.9)	
4.	Training course		62 (61.4)	39 (38.6)		0.127
		PPR	15 (14.9)	15 (14.9)	30 (29.7)	
		Never	47 (46.5)	24 (23.8)	71 (70.3)	

Other issues

TABLE 6 showed the application level of radiation protection related to type of hospital and hospital class. There was no difference between type and class of hospitals on application level of radiation protection.

TABLE 6. Application level of radiation protection in relation to the type and class of hospital

No	Item	Levels of radiation protection		Number (%)	p
		Low N (%)	High N (%)		
1.	Type of hospital	70 (69.3)	31 (30.7)		0.544
	Governmental	43 (42.6)	21 (20.8)	64 (63.4)	
	Private	27 (26.7)	10 (9.9)	37 (36.6)	
2.	Hospital class	70 (69.3)	31 (30.7)		0.060
	A	21 (20.8)	11 (10.9)	32 (31.7)	
	B	27 (26.7)	17 (16.8)	44 (43.6)	
	C	22 (21.8)	3 (3.0)	25 (24.8)	

TABLE 7 showed the risk assessment level of radiation protection in relation to the type of hospital. There was no difference between type of hospital an risk assessment level

TABLE 7. Risk assessment level of radiation protection in relation to the type of hospital

Item	Risk assessment level		Number (%)	p
	Low N (%)	High N (%)		
Type of Hospital	62 (61.4)	39 (38.6)		0.467
- Governmental	41 (40.6)	23 (22.8)	64 (63.4)	
- Private	21 (20.8)	16 (15.8)	37 (36.6)	

TABLE 8 showed the application level of radiation protection at nuclear medicine department. It demonstrated that half of radiographers at nuclear medicine department did not use protective gloves and syringe to prepare radioactive materials. In addition, they thought that the cautions posters and lights were not enough. But all of them reported that there was a protective container for radioactive wastes.

TABLE 8. Application level of radiation protection at Nuclear Medicine Department

Item	Answer	N (%)
Whether there is a protective gloves for radioactive material	Yes	2 (50.0)
	No	2 (50.0)
Whether there is a protective syringe for radioactive material	Yes	2 (50.0)
	No	2 (50.0)
Whether there are enough cautions (danger) posters or lights in the unit	Yes	2 (50.0)
	No	2 (50.0)
Whether there is a protective container for radioactive wastes	Yes	4 (100.0)
	No	0 (0.0)

DISCUSSION

Application Level of Radiation Protection

Cancer induction is the most important somatic effect of low-dose ionizing radiation. There is a long history of the association between radiation exposure and elevated incidence of cancer.[7] The respondents of this study were from different hospitals either governmental or private, and from different classes of hospital, A, B or C. The number of respondents was 101 of a total 124 radiographers at hospital in Yogyakarta Special Region who have worked with different periods. The analysis showed that females constituted about 46.5% of the total respondents.

Protecting patients, coworkers, and radiographers from excessive radiation exposure is the fundamental cornerstone to the practice of radiological technologists. Education plays an important role in ensuring compliance with protective standards and practices.[8] Training is required for all persons involved in the use of X-rays on humans for diagnostic purposes.[9]

The result showed that there was low application level of radiation protection in all groups (69.3%) such as in those who have worked more or less than 10 years, working on different medical imaging modality, have different academic levels and whether already have training courses on radiation protection or not. There was no difference in the application of radiation protection related to duration of working, type of medical imaging modality, academic level, and training on radiation protection ($p > 0.05$).

All workers who are likely to receive a radiation dose in excess of 1 mSv per annum require personal dosimeters.[10] The study revealed that 13.9% of the

radiographers did not have any device for monitoring the amount of radiation, and most of them were new radiographers. There was 32.7% of the radiographers who used badge film and the rest did not use it during working, and 18.8% of them were never use badge film.

The occupational dose limit to the fetus is 50 mrem/month during the 9 months of gestation. For monitoring purposes, radiation workers must declare their pregnancy in writing.[11] The study revealed that female radiographers who are employed in the radiology department during the pregnancy period, even when they worked at first trimester and with all types of imaging modalities, worked without any radiation monitoring device for their fetus. Some of them did not use personal badge film, and there was no program to protect the pregnant radiographers or control program on the amount of radiation exposed to the fetus. There were more than 90% of radiographers supported this result.

As a result, the hypothesis which stated that there was a difference in the application level of radiation protection among the radiographers at hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection was rejected. More importantly, the application level of radiation protection is not enough and needs significant improvements.

Awareness level of radiation protection

Increasing the awareness towards the hazards associated with ionizing radiation and its consequent disorders and diseases requires more attention as a part of a comprehensive radiation safety program.[5] Professionals radiologists have a duty to understand the concepts behind radiation protection so they can be fully equipped to protect themselves and their patients. The goal of ALARA is to provide a balance between producing a quality image during a diagnostic or interventional procedure and protecting the patient by using the possible lowest dose of radiation.[8] There was 80.2% of radiographers who understand the purpose of ALARA concept. It was indicated by the fact that there was no significant difference between the radiographers in relation to the duration of working, type of medical imaging modality, academic level, and training on radiation protection ($p > 0.05$).

The practice guidelines and technical standards state that safe and effective use of diagnostic and therapeutic radiology requires specific training, skills and techniques. Several professional skills and knowledge of the radiological technologist are 1) basic understanding of radiation biology; 2) basic understanding of patient protection practices; 3) continuing education with regular radiation protection modules.[8] This study showed that 36.6% of the respondents did not know the amount of radiation exposure to their body during last year. Therefore, they did not aware about the hazard of radiation on the cell and how it can cause many diseases especially cancer.

The result of this study showed that the radiographers participating in this study still did not have information about these issues. This may due to 1) they did not have any training course about radiation protection; 2) most of them have three years study (diploma) which may not be enough, so the responsible authority should improve their performance through training course; seminars and workshop and 3) medical imaging departments did not have an effective and detail radiation safety program to ensure adequate safety of patients and radiation workers.

As a result, the hypothesis which states that there was a difference in the awareness level of radiation protection (safety) among the radiographers at hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection was rejected. Generally, the awareness level of radiation protection is not adequate.

Risk assessment level of radiation protection

Any system of verification includes record-keeping. The requirements for recording occupational exposures usually were determined by the regulatory.[12] There was 61.4% of radiographers who thought that the risk assessment authorized of radiation was not enough and this percentage was high in all of the variables.

The use of continuing education materials and review of basic radiation biology and radiation physics is strongly encouraged the effective protective policies.[8] There was no significant

difference between duration of working, type of imaging modality, academic level and training course on radiation protection ($p > 0.05$). Therefore, the hypothesis that stated that there was a difference in the risk assessment in level of radiation protection (safety) among the radiographers at hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection was rejected. The risk assessment needs more application in the radiology departments.

Other issues

Radiological technologists should be encouraged to use protective equipment and procedures.[8] In relation to nuclear medicine unit, it seems there were a lot of risk for the radiographers because the radiographers did not use protective gloves to prepare the radioactive materials. There was no protective syringe to give the radioactive material to the patient. We found that half of the answers were answered by yes, but during the discussion it was found that syringe was not fit for use. The container wastes of radioactive material remained open all the time, and the radiation leakage from these wastes can be harmful to everyone in that area. The RSO is responsible for placing radiation warning signs on locations prescribed by the levels of radioactivity, certain exposure rates, and special working conditions.[11] There was no adequate warning signs to indicate it's a danger area for public.

CONCLUSION

It could be concluded that :

1. The application level of radiological protection was not sufficient. There wass no difference in the application level of radiation protection among the radiographers at hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection.
2. The awareness level of radiation protection was inadequate. There was no difference in the awareness level of radiation protection (safety) among the radiographers at hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection.
3. The risk assessment level for radiation protection was not enough. There was no difference in the risk assessment in level of radiation protection (safety) among the radiographers at hospital in Yogyakarta Special Region between duration of working, type of medical imaging modality, academic level, and training on radiation protection.

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