ORIGINAL ARTICLE

Knowledge of Radiation Dose and Awareness of Risks: a Cross-sectional Survey of Junior Clinicians

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ABSTRACT

Objectives: *To investigate among junior clinicians: (1) their level of knowledge and awareness of radiation dose of commonly performed radiological investigations and the associated risks of radiation exposure, and (2) their practice for obtaining informed consent for examinations involving high-dose radiation.*

Methods: *A questionnaire dealing targeting knowledge about commonly performed radiological procedures was distributed to clinicians under specialist training in a tertiary hospital. It addressed: (1) relative radiation doses, (2) associated risks of radiation exposure, (3) what they considered when requesting radiological examinations, and (4) their practice of obtaining informed consent for high-dose radiation examinations.*

Results: *Of 63 respondents, 57% (n = 36) to 90% (n = 57) underestimated the relative radiation dose of commonly performed radiological investigations. In all, 13% (8/63) incorrectly believed that magnetic resonance imaging involved radiation exposure and 5% (3/63) incorrectly believed that ultrasound involved radiation exposure; 98% (62/63) underestimated the 1 in 2000 lifetime risk of developing cancer after computed tomography of the abdomen; 79% (50/63) believed that diagnostic accuracy is the most important factor to consider when requesting radiological examinations; 27% (17/63) stated that they always explain the risks and benefits of radiation exposure to their patients when obtaining informed consent for examinations involving high-dose radiation.*

Conclusion: *This study demonstrated a deficit of knowledge about radiation dose, exposure, and risks among junior clinicians, which may cause them to request more radiological examinations than appropriate and high-dose examinations instead of lower-risk alternatives. Providing better radiation protection training may help improve their basic knowledge on the subject and reduce unnecessary patient exposure to radiation.*

Key Words: *Dose-response relationship, radiation; Education, medical; Radiation dosage; Radiation injuries; Radiation, ionizing*

中文摘要

年輕醫生對放射劑量的認識及風險認知的橫向調查研究

陸嬈、梁禮賢、鄭志成

目的：探討及了解低年資醫生以下兩方面的情況：（1）對一般放射性檢查中所使用的放射劑量的認識及認知，以及輻射暴露的相對風險；（2）當牽涉高劑量放射性檢查時，對於取得病人知情同意的做法。

方法：給一所三級醫院中正進行專科訓練的低年資醫生發放一份關於一般放射性檢查的問卷。問題圍繞著以下幾方面：（1）相對放射劑量；（2）輻射暴露引起的風險；（3）當要求病人接受放射性

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Submitted: 12 Nov 2010; Accepted: 20 Dec 2010.

檢查時會考慮的事情；（4）當牽涉高劑量放射性檢查時，對於取得病人知情同意的做法。

結果：共63位被訪者中，有57%（36位）至90%（57位）低估了一般放射性檢查中的相對放射劑量。有13%（8位）誤以為磁力共振檢查牽涉輻射暴露；另5%（3位）誤以為超聲波檢查牽涉輻射暴露。對於腹部電腦斷層檢查，98%（62位）低估了其後生命中發生癌症的1/2000風險機率。79%（50位）相信診斷準確性是進行放射性檢查中最重要的考慮因素。

結論：本研究發現低年資醫生對於放射劑量、輻射暴露及風險認知的認識不足，這樣可能會導致他們要求病人進行比實際需要為多的放射性檢查；而當可以使用危險性低的其他檢查時，他們可能會要求進行高劑量放射性檢查。為低年資醫生提供更佳的輻射防護訓練，可以提升他們對此課題的認識，及減少病人不必要的輻射暴露。

INTRODUCTION

Radiation has been widely used in the diagnosis and treatment of many diseases. Different imaging modalities involve radiation, and in particular, high-radiation-dose investigations such as computed tomography (CT) are increasingly resorted to.[1] Since radiation has proven adverse biological effects that vary with the dose and duration of exposure,[2-4] the level of clinician awareness of such matters including associated risks is important. Since clinicians refer patients for such investigations, they obviously bear some responsibility under the Ionizing Radiation (Medical Exposure) regulations.[5,6] Internationally, there has been an increasing concern that the knowledge of referring doctors about radiation doses of commonly performed imaging investigations and their awareness of associated risks of radiation exposure are insufficient.[3,5,7] Assessing areas of such knowledge deficiency among junior clinicians could help raise awareness and improve training about radiation protection. To the best of our knowledge, the current knowledge level of junior doctors in Hong Kong is not well-documented in the literature.

This study therefore aimed to investigate the knowledge, awareness of risks, and usual practice of junior clinicians, with regard to: (1) radiation dose of commonly performed radiological investigations and the associated risks of radiation exposure, (2) what to consider when requesting radiological examinations, and (3) how they obtained informed consent for examinations involving high-dose radiation.

METHODS

A cross-sectional study was conducted in a tertiary hospital. A questionnaire was designed and distributed to clinicians under specialist training prior to Fellowship admission (Appendix 1). Respondents were asked to estimate the radiation dose of various commonly performed procedures including CT of the abdomen or pelvis, CT brain, barium enema, intravenous urography (IVU), bone scintigraphy (Tc-99m), abdominal magnetic resonance imaging (MRI), and abdominal ultrasonography (USG). Since the respondents may not have been familiar with units of radiation doses, they were only asked to estimate the relative dose associated with each of these procedures in comparison to one chest radiograph. They were also asked the associated risks of radiation exposure. These questions were designed with reference to information from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the National Radiological Protection Board of United Kingdom (Health Protection Agency) [Appendix 2].[8-10]

Respondents were also asked to prioritise factors they would consider when requesting radiological examinations. These factors included diagnostic accuracy of the examination, radiation dose and associated radiation risks, availability (waiting time) for the radiological examination, and its costs. Respondents were also asked whether they outlined the risks and benefits of radiation exposure to patients, whenever they obtained informed consent for examinations involving high-dose radiation.

Respondents were divided into three groups according to their years of practice: one to three years of work experience; more than three years and up to five years of work experience; and more than five years of work experience. These cutoffs were used as they corresponded approximately with the basic, intermediate, and higher stages of specialty training.

The Hong Kong East Cluster research ethics review committee approved the protocol prior to the start of the study. Written informed consent was obtained from the respondents. All statistical analyses were carried out using the Statistical Package for the Social Sciences (Windows version 13.0; SPSS Inc, Chicago [IL], US). Statistical analyses entailed the chi-square test. The overall value for statistical significance was taken as $p < 0.05$.

RESULTS

A total of 117 questionnaires were distributed to clinicians under specialist training, of which 58, 33, and 26 questionnaires were distributed to those who had one to three years of working experience, more than three years and up to five years of working experience, and more than five years of working experience, respectively. A total of 63 questionnaires were completed (response rate, 54%), the numbers (and response rates) in the three respective groups being 31 (53%), 19 (58%), and 13 (50%). The respondents had a mean of three years and nine months of working experience after graduation from medical school, and a median of four years of working experience.

Regarding knowledge of radiation doses, 57% (36/63) to 90% (57/63) of the respondents underestimated the relative radiation dose of commonly performed radiological investigations (such as CT, barium enema and IVU; Table). In all, 8% (5/63) incorrectly believed that barium enema and IVU do not involve exposure to radiation; 19% (12/63) wrongly believed that bone scan does not involve radiation exposure; 13% (8/63) incorrectly believed that MRI involved radiation exposure, and 5% (3/63) incorrectly believed that ultrasound did so too.

Concerning awareness of risks associated with radiation exposure, 98% (62/63) of respondents underestimated the 1 in 2000 lifetime risk of developing cancer after having a CT of the abdomen, and only 30% (19/63) were aware of the increased risk of cataract. In all, 94% (59/63) were aware of the increased risk of developing leukaemia, whilst 98% (62/63) knew that radiation exposure during pregnancy increases the risk of abnormalities in the fetus.

Concerning factors they considered when requesting radiological examinations, 79% (50/63) of respondents believed that diagnostic accuracy of the imaging modality was the most important, 14% (9/63) believed it to be availability (waiting time), and 2% (1/63) each believed it to be the risk from radiation and the cost of the procedure (Figure 1). Of 63 respondents, five believed that the radiation risk was the second most important factor to consider when requesting radiological examinations.

When obtaining informed consent for examinations involving high-dose radiation, 13% (8/63) of respondents stated that they never explained the risks and benefits of radiation exposure to their patients, as opposed to 27% (17/63) who always did so, and 60% (38/63) stated that they sometimes did so (Figure 2).

In general, junior clinicians who had more than three

Table. Distribution of answers to questions about relative radiation dose of commonly performed radiological examinations compared to one chest radiograph.

Imaging modality	No. (%)			
	Does not involve radiation	Less than actual dose	Equal to actual dose	More than actual dose
CT abdomen or pelvis	1 (2%)	40 (63%)	22 (35%)	0
CT brain	1 (2%)	35 (56%)	23 (37%)	4 (6%)
Barium enema	5 (8%)	52 (83%)	6 (10%)	0
Intravenous urography	5 (8%)	43 (68%)	11 (17%)	4 (6%)
Bone scintigraphy (Tc-99m)	12 (19%)	28 (44%)	15 (24%)	8 (13%)
Abdominal MRI	55 (87%)	N/A	N/A	8 (13%)
Abdominal US	60 (95%)	N/A	N/A	3 (5%)

Abbreviations: CT = computed tomograpy; MRI = magnetic resonance imaging; US = ultrasonography; N/A = not applicable.

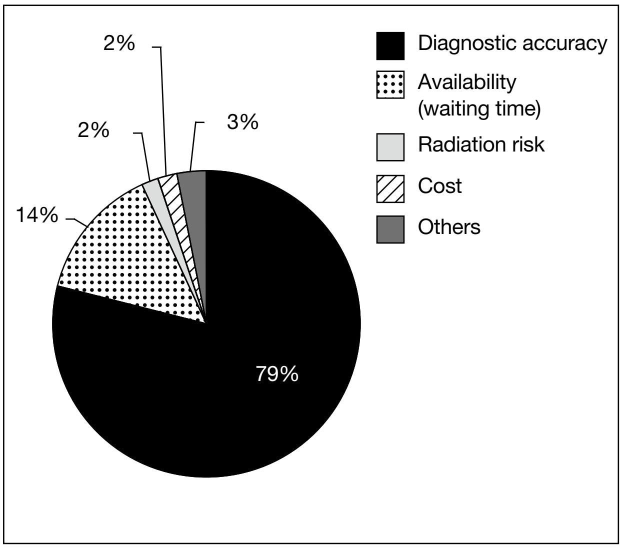

Figure 1. The most important considerations of junior clinicians when requesting radiological examinations.

years of working experience had a better knowledge than others of the relative radiation doses associated with a CT of the abdomen, pelvis, or brain, and with an abdominal USG. Compared to those with less than three years working experience, clinicians with more than five years of working experience had a better knowledge of relative radiation doses from CT brain. The relationship between years of working experience and knowledge about the relative radiation dose of CT brain was significant ($p = 0.039$).

85 to 90% of junior clinicians with different years of experience stated that they always or sometimes explained the respective risks and benefits of examinations entailing high-dose radiation exposure to their patients when obtaining informed consent, whereas 11 to 15% stated that they never did so. Our study demonstrated that junior clinicians with more years of practice were more likely to outline the risks and benefits of radiation exposure to their patients when obtaining informed consent for high-dose radiation examinations ($p = 0.03$).

DISCUSSION

Radiation has an important role in the diagnosis and treatment of disease, but also has proven adverse biological effects. Effective doses for diagnostic CT are similar to those received by Japanese survivors of the atomic bomb, who had a small but significantly increased risk of developing cancer from their radiation exposure.[1,11] This is of particular concern especially for paediatric imaging, and in situations where high radiation doses are used as a screening tool or repeatedly to monitor disease progression.

Like the studies conducted by Lee et al,[1] Arslanoğlu et al,[3] and Jacob et al,[5] our study also demonstrated that most junior clinicians surveyed were unable to provide an accurate estimate of the relative radiation dose of commonly performed radiological investigations. Most respondents underestimated the increased lifetime cancer risk associated with abdominal CT. Thus it appears that information regarding radiation dose and associated risks have not been well disseminated to junior clinicians. If referring doctors have adequate awareness of radiation dose, unnecessary examinations may be avoided, and high-dose radiation examinations might give way to lower risk alternatives.[7,12] Moreover, awareness of radiation dose and associated risks for non-radiologist is important due to their pivotal clinical role in providing accurate information about risks to patients.[5]

A proportion of respondents in this study answered that MRI and USG involved radiation, which was akin to findings in some international studies — Arslanoğlu et al[3] demonstrated that 4% and 27% of their participants, respectively, thought that abdominal USG and abdominal MRI exposed patients to ionising radiation; similarly, Jacob et al[5] noted that 28% and 10% of doctors, respectively, thought that magnetic resonance angiography and USG examinations involved as much radiation as a chest radiograph. Junior clinicians might therefore opt for radiological examinations owing to their incorrect understanding of alternative forms of imaging. Such basic knowledge deserves more emphasis during undergraduate medical training. Our study demonstrated that only a small proportion of junior clinicians considered radiation risk as a high priority when requesting radiological examinations, which is a shortcoming that needs also re-emphasis during training.

Information on radiation dose and the associated risks from exposure should be made more widely available to junior doctors. According to the Council of the European Union Medical Exposure Directive, a course on radiation protection should be part of the basic curriculum of medical schools.[13] Referring doctors should be educated on the basic aspects of radiation protection, radiation doses and their effects.[5] Education of referring clinicians regarding CT doses had been recommended at a national conference on CT dose reduction.[14] Information on radiation doses and associated risks of exposure could also be provided to junior clinicians via the radiological examination electronic requesting system.

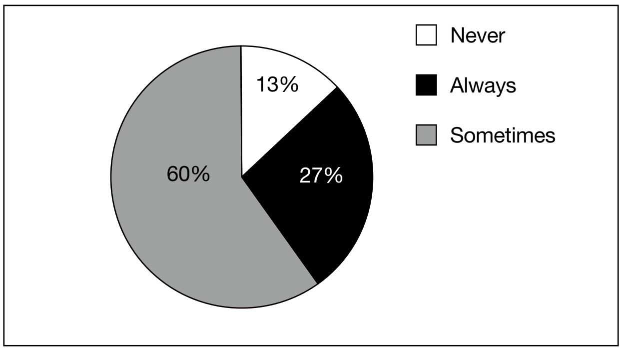

Figure 2. Distribution of responses on whether junior clinicians explain the risks and benefits of radiation exposure to patients when obtaining informed consent for examinations involving high-dose radiation.

With reference to the study conducted by Lee et al,[1] we also demonstrated that clinicians do not always outline the risks and benefits of radiation exposure to patients when obtaining informed consent for examinations involving high-dose radiation such as CT of the abdomen. Patients undergoing such examinations are often poorly informed about possible associated risks.[1,15] This might be related to their doctors' knowledge deficits of radiation doses, and communicating associated risks effectively to their patients. Radiologists could help educate junior clinicians about the extent of radiation doses and the associated risks following different procedures. Only such information is made available to patients can they themselves weigh the risks and benefits from their own perspective.[16,17] Possible methods might include providing clear information on radiation doses and reference ranges in radiology department waiting areas, as well as patient information pamphlets in outpatient facilities and elsewhere.

When obtaining informed consent for examinations involving high-dose radiation, junior clinicians with more years of practice were more knowledgeable about the relative radiation doses for CT brain and more likely to outline risks and benefits to the involved patients. The relationship between years of work experience and knowledge of relative radiation dose from CT of the brain and the practice of obtaining informed consent has not been well-documented in the literature. Further studies investigating these relationships and their possible causes might be helpful.

Limitations of this study include the small sample size, and that all the junior clinicians were recruited from a single tertiary centre. Further studies with a larger sample, further research into the effectiveness of radiation safety courses, and the extent and causes of unnecessary radiological examinations requested by junior clinicians may help reduce patient exposure to unnecessary radiation.

CONCLUSION

This study demonstrated that most junior clinicians underestimated the radiation dose of commonly performed radiological procedures. This deficit may lead them to request more and / or use unnecessarily high-dose examinations, despite the availability of lower-risk alternatives. Providing radiation protection training to junior clinicians in the basic curriculum of medical schools, and information radiation doses / risks via online resources or electronic request systems for radiological examinations may be beneficial for doctors and patients. Also, the importance of informing patients about these matters needs to be emphasised, so that they can properly weigh up the risks and benefits of radiological examinations from their own perspective.

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Appendix 1. Questionnaire

A. Demographic Information

1. Specialty: ___________________________________
2. Months/years of working experience as a doctor following qualification from medical school: ___________________________________

B. Relative radiation risks of commonly performed radiological examinations

If 1 chest radiograph (CXR) is taken as 1 unit of radiation exposure, what is the approximate equivalent effective dose to a patient undergoing the following investigations compared to a chest X-ray?

Number of units of exposure (1 CXR taken as 1 unit of exposure)	0	1 to <100	100 to <300	≥300
Computed tomography (CT) of abdomen or pelvis				
CT brain				
Barium enema				
Intravenous urography				
Bone scintigraphy (Tc-99m)				
Abdominal MRI				
Abdominal US				

C. Risks associated with radiation exposure

1. What is the risk of inducing cancer with one CT scan of the abdomen? (please circle as appropriate)
   (1) 1 in 200
   (2) 1 in 2000
   (3) 1 in 20,000
   (4) 1 in 200,000
2. Would exposure to ionising radiation increase the risk of developing the following conditions? (please circle as appropriate)
   Leukaemia (True / False)
   Fetal abnormality (when exposed to radiation in utero) (True / False)
   Cataract (True / False)

D. Patient consent

1. Do you explain the risks versus benefits of radiation exposure to patients when obtaining informed consent for examinations involving radiation? (please circle as appropriate?)
   (1) always
   (2) sometimes
   (3) never

E. Factors considered when requesting radiological examinations

What is the most important factor you would consider when requesting radiological examinations? (1: most important factor; 5: least important factor)

__ Accuracy of the radiological examination
__ Radiation dose and associated radiation risks of the radiological examination
__ Availability (waiting time) of the radiological examination
__ Non-radiation related risks of the radiological examination
__ Costs of the radiological examination

Appendix 2. Radiation exposures, equivalent period of natural background radiation, additional lifetime risk of fatal cancer for different radiological examinations and the range of doses that we considered acceptable in our questionnaire.[8,9]

Diagnostic procedure	Typical effective dose (mSv)	Equivalent no. of CXR	Accepted range (based on equivalent No. of chest radiographs)	Equivalent period of natural background radiation*	Lifetime additional risk of fatal cancer per examination†
CXR	0.02	1		3 days	1 in a million
CT abdomen/pelvis	7.8-10	390-500	>300	4.5 years	1 in 2000
CT brain	2-2.8	100-140	100 to <300	1 year	1 in 10,000
Barium enema	7	350	>300	3.2 years	1 in 3000
IVU	2.5	125	100 to <300	14 months	1 in 8000
Bone scan (Tc-99m)	4	200	100 to <300	2 years	1 in 5000

Abbreviations: CXR = chest X-ray; CT = computed tomography; IVU = intravenous urography.
* Natural background radiation, UK average = 2.2 mSv per year.
† Lifetime risk of dying from cancer (all sites, all races, both sexes) = 21.15%.[10]