EDITOR'S CHOICE

# Knowledge of radiation exposure in common radiological investigations: a comparison between radiologists and non-radiologists

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## ABSTRACT

**Background** Radiological examinations are commonly requested for patients to aid clinical diagnosis. However, many doctors do not realise how much radiation dosage their patients are exposed to during radiological investigations. This study aims to assess and compare the knowledge of radiologists and non-radiologists about radiation doses of common radiological investigations.
**Methods** A prospective questionnaire study of doctors about the dosage of commonly performed radiological investigations in a university teaching hospital in Hong Kong. Participants were asked to indicate the average dose of radiation (in mSv) for a standard chest x-ray exposure. Doctors were then asked to estimate the doses of radiation (measured in chest x-ray equivalents) for various radiological procedures. The results of radiologists and non-radiologists were compared.
**Results** 158 doctors (25 radiologists and 133 non-radiologists) completed the questionnaire. The overall accuracy was 40% for radiologists and 16% for non-radiologists. One-third of non-radiologists could not distinguish radiological examinations with or without ionising radiation. No non-radiologists correctly stated the radiation dose (in mSv) of a conventional chest x-ray, and 77% underestimated the dose of radiological examinations. For radiologists, only 32% were correct for the radiation dose of a conventional chest x-ray while 7% underestimated the radiation doses.
**Conclusion** Knowledge of radiation doses of investigation is generally inadequate among radiologists, and particularly poor in non-radiologists. Underestimation of radiation doses may expose patients to increasing radiological investigation and exposure to radiation hazards. Awareness of the radiation hazard of radiological examinations should be raised among medical professionals.

Although radiological examinations play an important role in daily medical practice in the hospital setting, patients are not adequately informed about the radiation dose they are exposed to when undergoing a radiological examination. Lee *et al*[1] found that nearly all patients undergoing CT scans were not informed about the radiation risk. This may be partly explained by inadequate knowledge among referring doctors concerning the radiation dose of commonly performed examinations,[2–4] regardless of years of clinical experience.[5–7] However, to date, limited study has been performed to assess knowledge among radiologists or to compare the results with non-radiologists.

As the majority of radiological examinations are initiated by non-radiologists, they should have some basic idea of the radiation dose of the examination before ordering the test. Radiologists should advise referring doctors on the best imaging modality that can provide the optimal answer to the clinical question that needs to be answered. On the other hand, radiologists should also remind referring doctors of the radiation hazards related to the examination; in particular, if the patient is young and repeated examinations are required to monitor the response to treatment. Both radiologists and non-radiologists should therefore have adequate knowledge of radiological examination doses, and work together to decide the best radiological examination for patients. The aim of this study was to assess knowledge about the radiation dosage of commonly performed radiological examinations among radiologists and compare that with non-radiologists.

## MATERIALS AND METHODS

Following institutional review board approval, 386 questionnaires listing the most commonly requested radiological investigations were distributed to doctors in the departments of emergency medicine, general internal medicine, surgery, paediatrics and radiology in a university teaching hospital with 1400 beds in Hong Kong. Questionnaires were distributed by both hard copies and by email to each doctor in these departments. A self-addressed envelope was included to facilitate the easy return of the paper copy while a dedicated email address was available for electronic return of the questionnaire for those who chose to complete the form electronically.

Participants were asked to fill in the exact value of the average radiation dose (in mSv) for a standard conventional chest x-ray exposure. This value was then used to represent a single unit dose of radiation. Participants were then asked to estimate the doses of radiation (measured in chest x-ray equivalents) for 18 common radiological procedures (table 1). The results of radiologists and non-radiologists were compared.

## RESULTS

One hundred and fifty-eight doctors (25 radiologists and 133 non-radiologists) completed the questionnaire, with a response rate of approximately 41% (158/386). The response rate of radiologists was 75% (25/33) while the rate among

**Table 1** Knowledge of radiation doses of commonly performed radiological examinations among radiologists and non-radiologists

| | Actual dose | Mean reported dose | | Correct response (%) | | Underestimates (%) | | Average degree of underestimation (in terms of times below actual dose) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Radiologist | Non-radiologist | Radiologist | Non-radiologist | Radiologist | Non-radiologist | Radiologist | Non-radiologist |
| Abdominal x-ray | 35 | 80 | 2 | 24 | 0 | 28 | 98 | 3 | 38 |
| Thoracic spine x-ray | 35 | 150 | 4 | 24 | 0 | 27 | 97 | 4 | 30 |
| Lumbar spine x-ray | 50 | 55 | 3 | 27 | 0 | 31 | 98 | 5 | 17 |
| Pelvis x-ray | 35 | 68 | 3 | 21 | 0.8 | 30 | 96 | 4 | 12 |
| Hip x-ray | 20 | 57 | 3 | 21 | 0.8 | 30 | 98 | 2 | 6 |
| CT head | 100 | 134 | 12 | 30 | 0.8 | 30 | 99 | 2 | 13 |
| CT thorax | 400 | 756 | 11 | 24 | 0 | 34 | 99 | 3 | 24 |
| CT abdomen | 500 | 873 | 10 | 27 | 0 | 29 | 99 | 2 | 23 |
| IVU | 120 | 150 | 6 | 21 | 0 | 30 | 97 | 4 | 20 |
| Barium enema | 360 | 423 | 10 | 21 | 0 | 31 | 98 | 4 | 31 |
| Barium swallow | 75 | 475 | 9 | 21 | 0 | 29 | 98 | 4 | 13 |
| Ultrasound abdomen | 0 | 0 | 0 | 100 | 100 | 0 | 0 | / | / |
| MRI brain | 0 | 0 | 2 | 100 | 65 | 0 | 0 | / | / |
| MRI abdomen | 0 | 0 | 2 | 100 | 65 | 0 | 0 | / | / |
| MRI limbs | 0 | 0 | 2 | 100 | 65 | 0 | 0 | / | / |
| Leg arteriogram | 100 | 245 | 7 | 21 | 0 | 30 | 96 | 3 | 14 |
| Thyroid isotope scan | 50 | 213 | 12 | 30 | 0 | 31 | 98 | 3 | 5 |
| PET scan | 250 | 500 | 15 | 20 | 0 | 30 | 97 | 2 | 16 |

All the x-rays were regarded as conventional, whereas CT were the single detector CT.
The actual dose and the mean reported dose were measured in chest x-ray equivalents.
IVU, intravenous urography; PET, positron emission tomography.

non-radiologists (133/353) was 38% (a similar percentage amount in a different subspecialty). The distribution of responses was as follows: general internal medicine (53, 33%); surgery (41, 26%); paediatrics (12, 8%); emergency medicine (27, 17%) and radiology (25, 16%). There were nine consultants (6%), 34 specialists (22%) and 115 residents (72%) among the responders.

### Knowledge of radiation doses of radiological investigations

The overall performances of non-radiologists and radiologists are shown in table 1. In general, radiologists performed better than non-radiologists. The total number of dose estimates provided by the 133 non-radiologists was 2394, of which only 383 (16%) were correct compared with 450 dose estimates by radiologists, 180 (40%) of which were correct.

The dose of a chest x-ray is 0.02 mSv. None of the non-radiologists correctly stated the radiation dose (in mSv) of a chest x-ray while 32% (8/25) of radiologists gave the correct answer. Seventy-seven per cent (102/133) of non-radiologists underestimated the dose of commonly performed radiological examinations compared with 24% (6/25) of radiologists (table 2).

Radiologists tended to overestimate the dose compared with non-radiologists (36% among radiologists vs 7% among non-radiologists, table 3). In general, senior radiologists (consultants and specialists) had poorer performances compared with junior radiologists (residents) as shown in table 2.

### Knowledge of imaging modalities

Approximately one-third of non-radiologists (33%, 44/133) thought that positron emission tomography and radio isotope scans did not involve radiation. A similar proportion of non-radiologists (34%, 45/133) thought that MRI involved radiation. All radiologists provided accurate answers for these questions.

## DISCUSSION

Radiation is a constant concern in modern medicine as it is known to be related to higher cancer rates. The estimated risk of cancer due to diagnostic x-rays in the UK and the USA are 500 and 5700 deaths per year, respectively.[8] It is even more important for children as their tissues are more radiosensitive and they have longer lifespans.[7] It is therefore important to stress the proper use of diagnostic x-rays, which requires an adequate knowledge of radiation doses.

Among all radiological examinations, the doses of CT are the highest. CT only comprises 4% of examinations, but makes a 40% contribution to the collective dose of radiation.[9] The impact of radiation doses by CT has been revisited recently due to the rapid increase in the number of CT performed as well as the introduction of multidetector CT (MDCT) scanners. MDCT has the advantage over single detector CT of shorter data acquisition time, greater coverage, decreased motion artefacts and improved sharpness of images. The use of MDCT is even more useful among paediatric patients as sedation can be avoided and superior images can be acquired.[7] This also partly explains the rapid rise in the number of CT examinations. However, MDCT gives a higher radiation dose than single detector CT[7 10] and poses greater radiation hazards. It is estimated that the number of CT examinations increases by 10% per year in the USA.[6] In Norway, the frequency of CT studies increased by a factor of 2.2 per year.[11] In our hospital, the use of CT has increased from 21 280 examinations in 2000 to 45 885

**Table 2** Comparison of the performance between senior radiologists and junior radiologists

| | Correct | Underestimation | Overestimation |
|---|---|---|---|
| Consultant and specialist radiologists | 27% (34/126) | 27% (34/126) | 46% (58/126) |
| Resident radiologists | 46% (149/324) | 22% (70/324) | 68% (220/324) |

**Table 3** Comparison of performance between radiologists and non-radiologists

| | Correct | Underestimation | Overestimation |
|---|---|---|---|
| Radiologists | 40% (180/450) | 24% (108/450) | 36% (162/450) |
| Non-radiologists | 16% (383/2394) | 77% (184/2394) | 7% (168/2394) |

examinations in 2009, more than double in just 10 years. The number of CT examinations in children has also increased significantly from 1147 in 2000 to 1525 in 2009 (~25% increase). The cancer risk related to medical radiation is therefore unavoidably increased. Measures such as as low as reasonably achievable (ALARA) have been repeatedly stressed in most paediatric radiology societies.[4–16]

From this study, one-third of non-radiologists do not realise the absence of radiation in MRI and the presence of radiation in positron emission tomography and radio isotope imaging. Similar results have been found in studies conducted elsewhere,[2 6] and this seems to be a common weakness among medical professionals across countries. As radiology and the impact of radiation on health are important issues and are commonly encountered in clinical practice, knowledge about radiation dose should be taught to students in medical schools. Not surprisingly, radiologists had better knowledge about radiation doses than non-radiologists due to their basic training in radiology physics; however, knowledge of this aspect is still inadequate and performance is suboptimal. Senior radiologists were observed to have a poorer performance than junior radiologists, which is in agreement with a previous study showing no significant relationship between radiologist years in practice and dose estimates.[1] Despite the greater awareness of radiologists of radiation hazards, they tend to overestimate the radiation doses of examinations. The findings of this study reinforce the importance of continuous medical education for specialists, which is important to enhance general knowledge about radiation in the medical profession.

The main limitation of the study is the low response rate. In addition, the responses of participants may be biased as they were not prohibited from access to an external reference or source of knowledge while completing the questionnaire. Despite this possible bias, the knowledge levels were still very low so this may suggest that true knowledge of these issues may be even worse in practice.

## CONCLUSION

Knowledge of radiation doses of common radiological tests is poor among non-radiologists and inadequate in radiologists. Underestimation of radiation doses may put patients at risk of undergoing increasing radiological investigations and thus increasing exposure to radiation hazards. Awareness of the radiation hazards of radiological examinations can be raised among medical professionals during undergraduate medical training or as part of continuous medical education programmes for specialists.

**Competing interests** None.

**Ethics approval** This study received institutional review board approval.

**Provenance and peer review** Not commissioned; externally peer reviewed.

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