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Research Article

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Radiation Awareness amongst Junior Doctors

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Abstract

Learning objectives: To evaluate junior doctors knowledge of ionising radiation exposure to patients in routinely requested investigations.

Background: Recent literature has suggested that junior doctors' knowledge of ionising radiation is inadequate. Advances in technology and availability have led to of these investigations being readily requested. Exposure is associated with adverse risks especially malignancy; therefore in accordance with the Ionising Radiation (Medical Exposures) Regulation (IR(ME)R), clinicians should be aware of radiation doses and their legal responsibility as referrers.

Findings and procedure details: A questionnaire was circulated to all junior doctors in the hospital, referrers were asked about radiation dosing, estimation of cancer risk and knowledge of referral systems and legislation.

Overall, our results showed that knowledge on this topic was poor. Of the 49 responses received 0% correctly estimated the dose of abdominal x-rays, CT head or CT thorax, abdomen and pelvis (CT TAP) scans. 43% underestimated the radiation dose of CT TAPs despite 89% of responders routinely requesting this investigation. 27% of responders thought that MRI and Ultrasound used ionising radiation. A total of 49% and 43% correctly estimated the risk of inducing malignancy in CT TAP and Chest X-ray respectively. 1/49 doctors knew of any legislation and could name IR(ME)R, 0/49 knew the Royal College of Radiologists i-Refer guidelines.

Conclusion: Knowledge of radiation doses, responsibility of referrers, and risk to patient safety was extremely limited. Education of junior doctors needs to be expanded to impress the importance and serious implications of these aspects. Possible solutions to implement this have been discussed.

Keywords: Radiation Awareness; Patient Safety; Education; Dosimetry

List of Abbreviations: CT: Computed Tomography; CXR: Chest X-Ray; CT TAP: Computed Tomography of Thorax Abdomen and Pelvis; NICE: National Institute of Health and Care Excellence; F1: Foundation Year 1 Trainees; F2: Foundation Year 2 Trainees

Introduction

Radiation awareness is a topic sparsely covered in both undergraduate and postgraduate curriculum in the United Kingdom [1]. Limited knowledge particularly amongst junior doctors is well documented [2-7]. At the forefront of patient care, junior trainees generally have less understanding of the basic sciences of imaging techniques, often opting for more generalised studies rather than tailored investigations which answer the specific clinical question [5,8].

Almost every speciality requires the input of a radiological investigation to diagnose and determine management plans for patients. Ranging from a staging CT in oncology, to interventional endovascular treatments; radiology continues to play a key role [9,10].

Although radiation-associated risks are well documented [11-14], the relative amount of teaching on this topic is minimal, with image interpretation being the primary focus. In the United Kingdom, studies have shown that radiation from diagnostic imaging leads to between 100-150 deaths annually [15]. With continuing advances in technology, imaging techniques such as CT are readily available; therefore every effort has to be made to reduce radiation doses to patients [16].

Every imaging department works towards the principle of achieving the best quality images with the lowest reasonably achievable dose of radiation (ALARA) [17,18]. Optimisation techniques during image acquisition such a beam collimation, x-ray filtration and tube current modulation, as well as setting CT parameters in accordance with patient weight, are well documented techniques used by scanner manufacturers and practitioners to protect patients from unnecessarily high doses of radiation [19-22]. However, in order to reduce cumulative lifetime doses, which may ultimately lead to detrimental effects, referrer's need to request every investigation appropriately and justify that the clinical benefit gained from the study will outweigh the potential harm from ionising radiation.

The updated British Safety Standards Regulation and the Ionising Radiation (Medical Exposures) Regulation 2000, both detail the safety measures required to insure there are no unnecessary radiation exposures, and that each member of the team is aware of their legal responsibility. There is now a greater onus on the referrer to be involved in the justification process and communicating potential risk to patients and carers [23,24].

The Health Protection Agency UK estimates the risk of radiation based on effective dose (E) [25]. The absorbed dose is the mean energy transferred to mass by ionising radiation. Once corrected for the type of radiation, it represents the equivalent dose. The equivalent dose is further weighted for specific tissues and organs, which are summated to produce the whole body dose in a specific examination [22,26,27].

These values are used as reference ranges to provide thresholds of safe levels of exposure in diagnostic imaging and to estimate the probability of risk of inducing fatal malignancy, as well as genetic detriment from irradiation during imaging25. The risk model set out in the International Commission on Radiation Protection (ICRP) publications is based on a 'reference person' of average age, gender, nationality and sex, derived from data of 7 populations (Shanghai, Osaka, Nagasaki, Hiroshima, Sweden, UK and USA), and hence can only provide a probability of risk [28-31]. An American study showed only 7% of patients were counselled regarding risks prior to their CT scan and only 9% of doctors routinely discussed radiation doses, suggesting that an understanding of these key concepts is vital to gain informed consent for imaging investigations [32].

A study by Puri *et al*., demonstrated that on retrospective reflection, 78% of emergency doctors in their study group felt between 25-50% of CT studies conducted were probably unnecessary; suggesting that proper evaluation and justification of risk/benefit for every investigation needs to be common practice to reduce unnecessary radiation doses to patients and wastage of resources [33,34].

The study also showed that clinicians with more clinical experience were more likely to explain the risks of radiation as well as look at previous exposures before requesting [33]. This suggests, in conjunction with gaining clinical experience, if junior doctors receive adequate radiation awareness training in the early formative stages of career development; this may lead to responsible requesting of investigations and regular communication of risks with patients as standard in their future career [1,6].

We aimed to evaluate junior doctors' knowledge of ionising radiation exposure to patients in routinely requested investigations and whether current teaching is adequate to arm doctors with the knowledge to request appropriate investigations in accordance with guidelines.

Materials and Methods

We conducted a prospective observational study, where a 9 point questionnaire (Figure 1) was circulated to all foundation year 1 and 2 trainees attending mandatory weekly teaching at the Royal Oldham Hospital Manchester UK (part of the Pennine Acute Hospital Trust). Foundation 1 and 2 years are the 2 years of mandatory training following a minimum of 5 years undergraduate training at medical school, where basic minimum competencies of clinical care are met.

Trainees were not informed of the study prior to being given the questionnaire and the completed surveys were collected at the end of the unrelated teaching session. The survey focussed on three themes. Firstly, teaching experience and investigations used in clinical practice. Secondly, understanding of radiation doses and associated risks; and finally, knowledge of legislation and guidelines. The data was then collated using Microsoft Excel and statistical analysis of question 5 data was performed using an independent t-test.

Results

A total of 70 questionnaires were distributed to the junior trainees, forty-nine fully completed questionnaires returned (response rate 70%). Results are described in relation to the theme.

Theme 1: Teaching and current practice

Questions 1 and 2 showed that only 24% of foundation doctors had had previous radiology teaching on dosimetry in diagnostic imaging either since starting training or at medical school. In practice, the most commonly requested imaging investigations were chest x-rays (98%), abdominal x-rays (96%), ultrasound studies (90%) and CT thorax-abdomen-pelvis (CT TAP- 82%).

Theme 2: Radiation exposure and associated risk

Questions 3-6 of the questionnaire explored participants knowledge of radiation doses. 18% of trainees correctly identified a chest x-ray having the equivalent radiation dose of 3 days annual background radiation. Table 1 outlines the equivalent of doses of radiation associated with different radiological imaging studies compared to the radiation exposure from one single chest x-ray. Despite 90% of trainees identifying a CT TAP as having the highest dose of radiation out of the options, 56% and 59% of foundation 1 and 2 doctors respectively underestimated the radiation dose of a single study and 51% overall underestimated the lifetime risk of inducing a fatal malignancy (1:2000). There was no statistical significance between the correct responses of foundation 1 and 2 trainees (p=0.5995). Interestingly 20% of trainees believed MRI studies to be associated with radiation doses and 5% of foundation 2 trainees associated ultrasound with radiation.

Radiation Awareness Audit *FY1 / FY2 (please circle)*

1) Have you had any formal teaching on radiation doses in diagnostic imaging?
Yes No

2) Which investigations do you routinely order as a foundation doctor?
(Please circle all that may apply)

Chest X-ray	Ultrasound	Barium studies	CT Head	CT Thorax Abdomen Pelvis	MRI	Abdominal X-ray

3) Which one of the following has the highest radiation exposure?

Chest X-ray	Ultrasound	Barium studies	CT Head	CT Thorax Abdomen Pelvis	MRI	Abdominal X-ray

4) How does the radiation dose from a chest x-ray compare to the annual dose of background radiation?

0 days 3 days 1 week 1 month 1 year 10 years

5) What is the relative equivalent radiation dose in 'Chest x-rays' for the following investigations? *(e.g. equivalent dose of a skull x-ray = 50 chest x-rays)*

Chest X-ray =
Abdominal X-ray =
Barium swallow =
CT Head =
CT Thorax Abdomen and Pelvis =
MRI =
Ultrasound =

6) What is the lifetime risk of inducing a fatal cancer by performing the following tests? *(please circle one of the following)*

CT TAP	1/100	1/2000	1/25000	1/1000000	1/10000000
CXR	1/100	1/2000	1/25000	1/1000000	1/10000000

7) Are you aware of the formal legislation regarding radiation doses for diagnostic imaging?
Yes No (If yes please specify which legislation you have come across)

8) Are you aware of the national referral guidelines for requesting investigations?
Yes No (If yes please specify which guidelines you have come across)

9) What does the acronym "ALARA" represent?

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Figure 1: 9 point Questionnaire circulated to junior doctors

Theme 3: Knowledge of guidelines and legislation

Questions 7-9 showed 94% of trainees were unaware of any legislation relating to radiation awareness or dosing and only 12% knew of any referral guidelines to aid in choosing the correct imaging investigation. None of these trainees were able to name i-Refer as a source, but had used the National Institute of Health and Care Excellence (NICE) CT head guidelines [35]. 10% could correctly describe the acronym ALARA to mean 'as low as reasonably achievable'.

Investigations	Correct Responses (%)		Underestimates (%)	
	F1	F2	F1	F2
CXR	100	96	0	0
Abdominal x-ray	0	0	94	84
Barium Swallow	0	16	94	80
CT Head	0	0	29	36
CT TAP	0	0	59	56
Magnetic resonance imaging	82	76	0	0
Ultrasound	100	84	0	0

CXR = Chest x-ray; A single arbitrary unit equating to the radiation dose of a single CXR
Participants asked to estimate the radiation doses of different imaging modalities compared to the number of chest x-rays
Table 1: Responses to the radiation exposure component of the questionnaire outlining correct responses and underestimates of radiological investigations

Discussion

Overall our results demonstrate that knowledge of radiation awareness amongst junior doctors is poor, a similar trend is seen in studies in the UK and abroad [2-4,36-40]. A limited understanding of radiation doses and associated risks may lead to unnecessary exposures, with lifetime cumulative doses potentially leading to fatal malignancies [11,14,41].

Exposure is associated with adverse risks such as skin erythema, hair loss, sterility and malignancy [42-44]. Doses as low as 10mSv (the dose of a CT thorax abdomen and pelvis) will induce a fatal malignancy in 1 in 2000 patients [14,16]. With 51% of our cohort underestimating this risk, it is imperative that junior doctors have up to date knowledge of radiation doses, and routinely communicate the risk and benefits of these investigations with patients to obtain informed consent [41,45].

Often there may be multiple investigations, which will answer the clinical question. The Royal College of Radiologists 'i-Refer' guideline is a comprehensive online pathway which details symptoms, the most appropriate imaging investigation, and information on radiation dosing [34]. Training and access to this guideline needs to be encouraged as 88% of our cohort had no knowledge of this essential tool which could help reduce the number of unnecessary requests and potential risks to patients.

Ultimately, teaching and continued training will help to improve doctors understanding of radiology. 5% of trainees associated ultrasound with radiation exposure despite 90% routinely requesting this modality. This has also been seen in other studies where 4-15% of doctors incorrectly considered ultrasound to use radiation [8,37,44,46,47]. Teaching needs to focus not only on image interpretation, but also on the fundamental science of the imaging techniques [48].

The Royal College of Radiologists has a detailed curriculum outlining teaching topics and cases [1]. These could be implemented at a postgraduate level, as 76% of trainees had had no formal teaching during their formative stages of career development. This theme is consistent with similar studies where 68%-70% of doctors surveyed felt they needed more radiology teaching [6,49,50]. Interestingly our study showed no statistical significance in correct responses between foundation 1 and 2 trainees. In an Australian study responses regarding radiation awareness from junior and senior emergency department doctors were similar (p=0.75) [49], suggesting more clinical experience did not necessarily equate to increased knowledge in this subject and the need for continued development and training is essential.

In order to increase radiation awareness amongst junior doctors, we suggest incorporating a teaching session at induction training outlining the associated radiation risks of certain imaging investigations, how to access i-Refer guidelines, and how to effectively communicate the risks and benefits of these investigations to patients. We also suggest producing patient information leaflets for imaging involving radiation, which can be given prior to an investigation as part of gaining informed consent. We feel this would be beneficial to medical staff to insure patient safety.

Conclusion

Knowledge of radiation doses, awareness of responsibility of referrers, and risk to patients was extremely limited amongst junior doctors. Education needs to include not only image interpretation, but radiation awareness as well. Focussing on these aspects will move towards minimising wastage of resources, reducing unnecessary radiation exposures and improving patient safety.

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