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Original Article

Radiology Section

Interns, Postgraduate Residents and Non Radiologist Doctors Awareness about Ionising Radiation in Diagnostic Imaging Investigations in a Tertiary Hospital, Bengaluru

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ABSTRACT

Introduction: Radiological investigations that use ionising radiations are known to pose health risks to patients subjected to them. Hence, exposure of patients to ionising radiation during radiological investigations must be As Low As Reasonably Achievable (ALARA) due to health concerns and the referring clinician must be able to rationalise this.

Aim: Assessment of the level of awareness and knowledge of interns, postgraduate residents and non-radiologist doctors regarding ionising radiation involved in diagnostic imaging investigations and as a feedback were suggested how education regarding the same could be improved.

Materials and Methods: A prospective study was conducted during the period between December 2015 and February 2016 in Bowring and Lady Curzon hospital attached to Bangalore Medical college involving interns, post-graduate residents and non-radiologist doctors who were asked to complete a standard set of pretested questionnaire concerning demographics, knowledge and awareness of radiation hazards and doses from imaging procedures and their preferred method of learning.

Results: A total of 138 questionnaires were distributed and all were completed (100% response rate). 20 were interns (15%), 68 were post graduate residents (49%) and 50 were senior doctors other than radiologists (36%). A very important observation found in this study was that, 26 participants (18.8%) either did not know that ultrasound does not produce ionising radiation or incorrectly believed that it emitted one chest X-ray equivalent ionising radiation. 90.6 % of participants correctly answered that CT-scan increases the lifetime of developing cancer which is commendable.

Conclusion: The results of this study points towards inadequate knowledge and partial lack of awareness of non radiologist doctors regarding ionising radiation in diagnostic imaging investigations and emphasises us to provide more knowledge in a medium easily comprehensible to non radiologist doctors so that their awareness regarding the same is increased.

Keywords: Knowledge, Questionnaire, Radiological investigations, Undesirable effects

INTRODUCTION

Diagnostic imaging investigations utilised in medicine contribute the highest source of radiation to which human beings are exposed to apart from natural background radiation [1]. Most of the procedures in Radio-diagnosis and nuclear medicine produce ionising radiations whose dose depends on several factors which are related to the patient and equipment [2]. There is direct relationship between exposure to radiation and development of cancer and several studies have proven it [3-7]. Evidences suggest that exposure of foetus in utero during pregnancy may lead to wide range of malformations. Children in the growing age (upto 10 years) are at higher risk when exposed to radiation and have a greater likelihood of 2-3 times more than adults in developing leukaemia [7]. As Low As Reasonably Achievable (ALARA) is the principle which the referring clinician must adhere to while subjecting the patient to a radiation based medical imaging procedure and must be well aware of the approximate amount of radiation dose and its potential adverse effects [8]. In a questionnaire based survey involving doctors of clinical specialities, conducted

in the state of Punjab, India in 2015, majority (55-70%) of the clinicians undervalued the radiation doses from routine imaging. About 50% of the doctors overestimated the dose form CT and about 12% of clinicians had wrong notions regarding Magnetic Resonance Imaging (MRI) and ultrasound that they emitted ionising radiation when used for diagnostic imaging. The study pointed out that there was inadequate knowledge of radiation risks among clinicians and there was a lack of referral guideline [9]. Clinicians lack awareness regarding radiation dose and the consequent harmful effects to the patients produced during radiological investigations, this was identified by a study conducted in Northern Ireland. It was concluded that if information is imparted about Ionising radiation and their risks, then there is an increase in awareness and clinicians knowledge about radiation doses in diagnostic imaging investigations, also radiology courses if incorporated in curriculum imparted knowledge and awareness and this was identified in this study [10].

Hence, there is a need to educate clinicians and other doctors about ionising radiation with regards to diagnostic imaging investigations and procedures so that they are able to minimise unnecessary exposure of ionising radiation to their referred patients by choosing the best possible diagnostic imaging investigation and at the same time emitting least ionising radiation for solving the clinical problem and helping the patient. In India, at the undergraduate level in medicine there is lack of structured radiology curriculum in imparting knowledge and awareness to students pursuing medicine and this may lead to lack of knowledge and awareness regarding ionising radiation in diagnostic imaging procedures, once the student becomes an intern and works in a hospital.

Therefore, we assessed the level of awareness and knowledge of Interns, postgraduate residents and non radiologist doctors regarding ionising radiation involved in diagnostic imaging investigations and as a feedback were suggested how education regarding the same could be improved.

MATERIALS AND METHODS

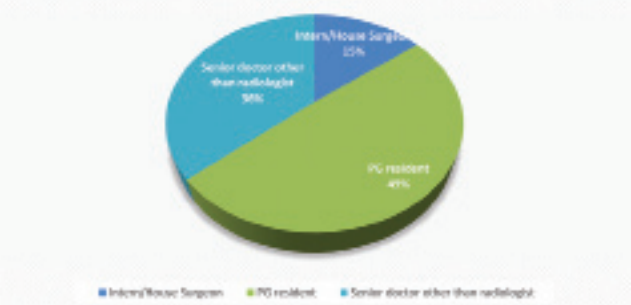
A prospective study was conducted in between the period of December 2015 and February 2016, in Bowring and Lady Curzon Hospital attached to Bangalore Medical College involving all the Interns, post-graduate residents and non radiologist doctors (total of 138 doctors) working during that period were asked to complete a standard set of self administered pretested structured questionnaire concerning demographics, knowledge and awareness of radiation hazards and doses from imaging procedures and their preferred method of learning. All the questions were in multiple choice formats ranging from 3-6 choices. The authors distributed the questionnaire with the help of volunteers by visiting various departments in the hospitals.

The distributed questionnaires were filled up and were returned to the authors. Data was analyzed using SPSS software (latest version) for calculating the means, cross tabulations and chi square test in which the level of significance was kept at $p<0.05$. This study was approved by the Institutional Ethical Review committee, Bangalore Medical College and Research Institute. Before collecting the data, subjects were informed regarding the objectives of the study, benefit of the study findings and informed verbal consent was taken prior to the administration of the questionnaire.

RESULTS

A Total of 138 questionnaires were distributed and all were completed (100% response rate). 20 were Interns (15%), 68 were post-graduate Residents (49%) and 50 were Senior doctors other than radiologists (36%).The percentage of participants is depicted in a pie chart [Table/Fig-1].

Majority of the participants (92%) believed that the knowledge of the ionising radiation is very important. The overall result is summarised below in [Table/Fig-2].



[Table/Fig-1]: Designation.

Questionnaire Response	No.	Percentage (%)
Important	127	92.0
Not Important	4	2.9
Don't Know	7	5.1

[Table/Fig-2]: Distribution of study subjects according to their thinking about the need for knowledge of Ionising radiation in radiological investigations (N = 138).

A large number of participants (81.9%) correctly answered that "Sievert" is the SI unit of ionising radiation while only less than half (41.3 %) correctly answered the approximate radiation in mSv (Millisievert), during exposure in chest X-ray (PA and Lateral views), the overall result is summarised in [Table/Fig-3].

A very important observation found in this study was that, 26 participants (18.8%) either did not know that ultrasound does not produce ionising radiation or incorrectly believed that it emitted one chest radiograph equivalent ionising

Questionnaire Response (mSv)	No.	Percentage (%)
0.01	5	3.6
0.1	57	41.3
1	36	26.1
Don't Know	40	29.0

[Table/Fig-3]: Distribution of study subjects according to the response regarding approximate radiation in mSv, during exposure in chest X-ray (PA and Lateral views) (N = 138).

radiation. Similarly, more than a quarter of the participants (29%) either did not know that MRI spine does not produce ionising radiation or incorrectly believed that it emitted one chest radiograph equivalent ionising radiation.

Regarding organ rating in terms of their sensitivity to ionising radiation it was heartening to see that 81.2% of participants correctly answered that lymphocyte and blood forming tissues were very sensitive to ionising radiation.

In all 90.6% of participants correctly answered that CT-scan increases the lifetime of developing cancer which is commendable.

Only 20.3% of the participants received education in the form of lectures, tutorials or courses regarding ionising radiation while a whopping 79.7 % did not receive any formal education regarding the same.

Following is the feedback we received from the participants regarding their choice of the kind of education they would like to receive to improve their knowledge and awareness regarding ionising radiation [Table/Fig-4].

Questionnaire Response	No.	Percentage (%)
Lectures	43	31.2
Tutorials/ Workshops	73	52.9
Case Studies	8	5.8
Learning Module	14	10.1

[Table/Fig-4]: Distribution of study subjects according to their choice of kind of education which help them the most to raise awareness of ionising radiation (N = 138).

DISCUSSION

Diagnostic radiology is indispensable in the clinical evaluation of the patients and helps in the accurate diagnosis and treatment of diseases and in follow up of the treatment.

Radiation dose from medical imaging has become a controversy and a matter of debate in the press. This is the result of recent articles on the increased cancer risks associated with diagnostic medical imaging [11-13].

Ionising radiation has undesirable biological effects on living tissues and these adverse effects vary according to the dose of the radiation and duration of exposure [11,14-16].

Absorbed dose, measured in "Gray" (Gy), quantifies the energy deposited per unit mass. The energy deposition of 1J/kg of tissue is the equivalent of 1Gy. Different types of radiation produce different biological effects hence the term "Dose Equivalent" is often used instead of the term "Absorbed Dose". The dose equivalent is the product of the absorbed dose and a radiation weighting factor and is expressed in "Sieverts" (Sv). In Diagnostic Radiology 1 Gray is equivalent to 1 Sievert since the radiation weighting factor for X-rays and Gamma rays is the same that is 1 [17]. Radiation doses in medical imaging are typically expressed as millisieverts (mSv) since the quantity of radiation is less.

Two types of cellular damage, deterministic and stochastic effects, are produced by radiation despite natural repair by the body. Radiation induced dermatitis is a perfect example of a dose related effect of radiation which occurs above a threshold and is termed "Deterministic effect" [18]. Carcinogenesis and mutation are good examples of radiation effects which are termed as "stochastic" in which the cell does not die.The probability of a stochastic effect increases with dose (probably with no threshold, an assumption based on molecular knowledge of carcinogenesis: a very small X-ray dose can cause a base change in DNA), but the severity of the outcome is independent of the dose [19]. The usual time period after which carcinogenesis occurs and becomes diagnosed is an average of 5 years [13] however, in some cases it may be as long as 10 to 20 years or even longer [14]. Several mathematical models are utilized to extrapolate the experience of Japanese survivors of atom bombs explosion (exposed to moderate and high radiation doses) and to estimate the risks caused by ionising radiation doses. These survivors provide valuable insight regarding estimation of risks [20-22]. Also evidence of excess risk of fatal cancer in people exposed to high energy radiation also come from other types of studies, such as those involving populations exposed to radiation emitted from other sources like radiotherapy treatments occupational exposure and environmental exposure [15].

Ionising radiations are emitted during radiography, fluoroscopy, angiography and computed tomography (CT) besides nuclear medicine examinations, and the effective radiation dose depends on several factors, namely the patients (age and size), technical factors (equipment parameters and procedure duration) as well as model of the equipment [2].

Following are the approximate effective radiation doses in common diagnostic imaging procedures, summarized in the [Table/Fig-5] [23].

Results of our study showed that, 26 participants (18.8%) either did not know that ultrasound does not produce ionising radiation or incorrectly believed that it emitted one chest radiograph equivalent ionising radiation. Similarly,

Procedure	Average Effective Dose (mSv)	Range Reported in the Literature (mSv)
Bone Density Test	0.001	0.00–0.035
X-Ray, Arm or Leg	0.001	0.0002–0.1
X-Ray, Panoramic Dental	0.01	0.007–0.09
X-Ray, Chest	0.1	0.05–0.24
X-Ray, Abdominal	0.7	0.04–1.1
Mammogram	0.4	0.10–0.6
X-Ray, Lumbar Spine	1.5	0.5–1.8
CT, Head	2	0.9–4
CT, Cardiac for Calcium Scoring	3	1.0–12
Nuclear Imaging, Bone Scan	6.3	
CT, Spine	6	1.5–10
CT, Pelvis	6	3.3–10
CT, Chest	7	4.0–18
CT, Abdomen	8	3.5–25
CT, Colonoscopy	10	4.0–13.2
CT, Angiogram	16	5.0–32
CT, Whole body	variable	20 or more
Nuclear Imaging, Cardiac Stress Test	40.7	

[Table/Fig-5]: Imaging procedures and their approximate effective radiation doses.

more than a quarter of the participants (29%) either did not know that MRI spine does not produce ionising radiation or incorrectly believed that it emitted one chest radiograph equivalent ionising radiation. This overestimation or incorrect assumption leads to physicians and clinicians under utilising the services of ultrasound or MRI and more seriously those patients will either be investigated with diagnostic investigations actually emitting ionising radiation like radiography, CT-scan or nuclear medicine studies which will lead to a cumulative increase in dose equivalent for the patient or will not be investigated leading to delay in diagnosis or incorrect diagnosis and thereby a delay in treatment or incorrect treatment.

Shiralkar et al., demonstrated that 97% of doctors underestimate the actual ionising radiation dose received by the patient, and 5% claimed US and 8% claimed MRI used ionising radiation [24].

In a study by Jacob et al., about 10% thought that Ultrasonography produced ionising radiation and 28% thought that MRI produced ionising radiation and less than one third doctors accurately estimated the actual equivalent dose of imaging investigations in comparison to chest radiographs [25].

In a study by Singh et al., about 50% of the doctors overestimated the dose form CT and about 12% of clinicians had wrong notions regarding Magnetic Resonance Imaging (MRI) and ultrasound that they emitted ionising radiation when used for diagnostic imaging [9].

In our study, majority of the participants (92%) believed that the knowledge of the ionising radiation is very important.A large number of participants (81.9%) correctly answered that "Sievert" is the SI unit of ionising radiation while only less than half (41.3 %) correctly answered the approximate radiation in mSv (Millisievert),during exposure in chest X-ray (PA and Lateral views). About a quarter of the respondents (24.6%) incorrectly answered the chest X-ray equivalent radiation in CT scan of the abdomen.

A study of 45 Emergency Department physicians in Yale found that, 44% of the respondents greatly underestimated the radiation dose of an abdominopelvic CT [26].

Majority of doctors (97%) underestimated the dose estimation as per a study in two hospitals in South Wales and Oxford [24].

In our study it is reassuring that 90.6 % of participants correctly answered that CT-scan increases the lifetime of developing cancer.

A study in Yale showed that 9% of emergency doctors and 47% of radiologists surveyed believed CT increased cancer risk [26].

In a study published from Northern Ireland revealed that only 19% of doctors were aware of the association between medical radiation and increased cancer risk [Table/Fig-6] [10].

Parameters	Wrong belief that USG produces ionising radiation	Wrong belief that MRI produces ionising radiation	Knowledge that CT-scan increases life time risk of cancer
Present study	18.6%	29%	90.6%
Shiralkar et al.,[24]	5%	8%	-
Jacob et al.,[25]	10%	28%	-
Singh et al.,[9]	12%	12%	-
Yale et al.,[26]	-	-	9%
Northern Ireland study [10]	-	-	19%

[Table/Fig-6]: Comparison between results of present study and other similar studies.

In our study surprisingly majority of the participants 79.7% told that they did not have any formal education in the form of lectures, tutorials or courses regarding ionising radiation, and all of them wanted some form of education to raise their awareness regarding ionising radiation which

is tabulated below [Table/Fig-7].

Questionnaire Response	No.	Percentage (%)
Lectures	15	10.9
Tutorials/ Workshops	6	4.3
Combination of Both	7	5.1
None	110	79.7

[Table/Fig-7]: Distribution of study subjects according to their education in the form of lectures, tutorials or courses regarding ionising radiation (N = 138).

The message we got from this study was that education is ultimately the only method by which doctors can raise their level of awareness regarding ionising radiation in diagnostic imaging investigations. In our study those who had higher education qualifications scored higher with respect to questions regarding undesirable effects of radiation (Increased Lifetime Risk of Cancer With CT scan) (p=0.03)(s); This significant difference may be due to higher updating of knowledge by post graduate residents, senior doctors (other than radiologists) than interns by attending conferences, CME programs, seminars, panel discussion etc.

Two of the most important concepts in reducing radiation doses involved in diagnostic imaging investigations are:

1) Justification

The referring medical practitioner is responsible for ensuring that a diagnostic procedure involving ionising radiation is necessary for a patient's care and that the radiation dose from the procedure is expected to do more good than harm, a concept designated as Justification by the ICRP (International Commission on Radiological Protection) [21].

2) Optimisation

The radiological medical practitioner (who is not always a radiologist) is responsible for ensuring that the radiologic procedure provides images adequate for diagnosis and treatment while keeping the radiation dose As Low As Reasonably Achievable (ALARA), a concept designated as optimisation by the ICRP [21].

LIMITATION

Since this study was a questionnaire based study and evaluates the knowledge and attitude of doctors towards the hazards of radiation involved in diagnostic imaging procedures, a possibility of recall bias cannot be eliminated.

1) The study group comprised of doctors (Interns, post graduates and non radiologist doctors) working in a tertiary hospital attached to a Government Medical College (Bangalore Medical College) and hence the doctors may be exposed to more teaching and may regularly update their medical knowledge through participating in conferences etc., while other doctors working in non teaching hospitals and hospitals not attached to medical colleges may or may not be aware of the hazards and knowledge regarding radiation doses involved in diagnostic imaging investigations, hence we cannot extrapolate the study results to all doctors.

CONCLUSION

The results of this study clearly highlights the lacuna in the knowledge of non radiologist doctors regarding ionising radiation in diagnostic imaging investigations and emphasizes us to provide more knowledge in a medium easily comprehensible to non radiologist doctors so that their awareness regarding the same is increased.

RECOMMENDATIONS FOR DOCTORS

1) Need to be aware regarding radiation doses involved in diagnostic imaging investigations.

2) To consider a diagnostic imaging investigation with the minimum radiation dose to provide the necessary information required for diagnosis, treatment or follow-up of the patient and also to consider MRI and ultrasound as appropriate alternatives since they do not involve ionising radiation.

3) All requests for imaging studies should be justified (e.g., when all benefits and risks are considered, the study should be expected to do more good than harm).

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