



## Physicians Knowledge of Radiation Risk in Prescribing CT Imaging in Moroccan Hospitals

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### Authors' contributions

This work was carried out in collaboration between all authors. Author SS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BA, AEK and AS managed the analyses of the study. Authors OKH and AC managed the literature searches. All authors read and approved the final manuscript.

### Article Information

DOI: 10.9734/BJAST/2017/32491

Editor(s):

(1) Samir Kumar Bandyopadhyay, Department of Computer Science and Engineering, University of Calcutta, India.

Reviewers:

(1) Zhen Yuan, University of Macau, Macau, China.

(2) Rasha Farouk Abdellah, Suez Canal University, Egypt.

(3) Nina Tuncel, Akdeniz University, Turkey.

Complete Peer review History: <http://www.sciencedomain.org/review-history/18717>

Original Research Article

Received 28<sup>th</sup> February 2017

Accepted 17<sup>th</sup> April 2017

Published 21<sup>st</sup> April 2017

### ABSTRACT

**Aims:** This study aims to assess physicians' knowledge on patients' radiation protection during their computed tomography (CT) scan prescriptions.

**Materials and Methods:** A standardized questionnaire in multiple-choice format consisted of four sections with a total of eight questions based on the literature review. A total of 153 (59%) completed questionnaires were returned from six different hospitals in Morocco.

**Results:** Only 38% of prescribers took into account the ratio benefit/risk related to x-rays. Just 10% of doctors explained the risk related to x-rays to the patients. One out of four physicians has

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correctly estimated the effective dose received by patient during a CT scan of abdomen pelvic examination. 63% of physicians underestimated the lifetime risk of fatal cancer attributable to a single CT scan of the abdomen pelvic. Only 14% of practitioners have received formal training on risks to patients from radiation exposure.

**Conclusion:** The present study demonstrated the limited knowledge of radiation exposure among Physicians' and Residents and this can be improved through educational and training programs.

*Keywords: Medical exposure; CT scan; patients' radiation protection; X-ray risks.*

## 1. INTRODUCTION

Every year the number of patients undergoing diagnostic radiology is increasing, in particular computed tomography (CT) scanning [1,2]. Radiation doses per scan have increased by up to 40% although the improvements in CT scanning technology [3]. The multidetector CT scanners expose patients to higher radiation doses than older single-detector CT scanners, despite the technological advances achieved today in the scanner industry [4].

In any diagnostic procedure the dose of radiation given should be enough to answer the relevant clinical question but as low as reasonably achievable to minimise the risk to the patient [5]. Modern imaging equipment allows adjustment for patient size and anatomy [6]. This is important, as the lifetime attributable risk of fatal cancer for children exposed to radiation is substantially higher than for adults [7].

From epidemiological data, the smallest dose of x-radiation for which there is good evidence of carcinogenicity is around 10–50 mSv for a severe exposure and around 50–100 mSv for a prolonged exposure. Thus, the probability of developing cancer after x-ray examinations depends on the dose and duration of the exposure. The dose received during one chest radiograph is 0.02 mSv and that for an abdominal CT is 9 mSv [8]. The lifetime attributable risk (LAR) of carcinogenesis from radiation exposure also varies indifferent age groups. The radiation-induced lifetime cancer mortality was estimated to be around 1/1000 from pediatric CT scanning [9]. This is about twice the risk for adults [10].

Despite it has long been approved that ionizing radiation is a confirmed human carcinogen, growing interest has been expressed in the literature that although the increased use of radiological imaging in clinical practice [11], the knowledge medical professionals possess concerning the radiation doses delivered during

different radiological procedures is inadequate [12,13], regardless of the fields of expertise.

Alarming studies from the United Kingdom and the United States have suggested that there is a very common underestimation of radiation doses among physicians and paediatricians [3,14]. 75% of pediatric surgeons underestimated the radiation dose from a CT scan compared to that from a chest radiograph, during a study published in the Journal of Pediatric Surgery in 2007 [15]. Moreover, the risks associated with CT scanning in general did not discussed by most of the physicians with their patients. In a questionnaire study at Clinical Radiology Journal published in 2004 showed that, only 12.5% of doctors were conscious of the 1/2000 risk of induction of a fatal cancer from abdomen CT scan [16]. Another study, in which patients undergoing CT of the abdomen were surveyed, published in Radiology Journal in 2004, showed that only 7% of these patients were received information's about the risks and benefits of a CT scan. Important to constate that in the above studies many of the physicians interviewed underestimated the radiation patients are exposed to [17,18,19]. Another study showed that training sessions in patients' radiation protection could significantly improve physicians' awareness [20].

It is very important that physicians are well trained in diagnostic imaging by ionising radiation and have good knowledge of the associated risks. This is especially significant in each health structure, where many radiological imaging exams are requested each day, often in a time-pressured environment.

The lack of data on medical radiation exposure [21-23] and on doctors' knowledge and their related work practices in Morocco [24] pushed us to undertake this study. Given the diversity in experience, the goals of this study is to evaluate the perception of the risks to patients from radiation exposure by the physicians, their background training, and their practices of

requesting diagnostic imaging and informing patients of risks.

## 2. MATERIALS AND METHODS

### 2.1 Participants

Medical specialists, surgeons, general practitioners and residents working in six different hospitals in Morocco were selected at random and were asked to fill out the anonymous questionnaire, which took ~5 min. They were not pre-informed about the questionnaire and were supervised while completing the form to ensure their answers were unaided. A total of 153 questionnaires were completed out of 260 administered in paper format, 56 Medical specialists (i.e. Radiotherapist, Oncologist, Nuclear Medicine, Paediatrics, Dermatologist, Traumatologist and Neurologists), 48 General practitioners, 35 Surgeons and 14 Residents. Their years in practice ranged from 0 to >25 years.

### 2.2 Questionnaire

A standardized questionnaire in multiple-choice format consisted of four sections with a total of eight questions based on the literature review. The 4 sections of the questionnaire were designed to evaluate the current practice regarding the prescriptions of CT examinations for patients. The first section requested demographic data of prescriber (Institution, service, gender, qualification, years of experience). The second section included questions and it aimed at investigating how frequently doctors prescribe CT scans, use a guide of medical imaging examinations before prescription. Also it focused on their knowledge of using x rays benefit / risk ratio and asked if patients were routinely informed about possible health risks. The third section tackled doctors' knowledge on radiation doses which can be evaluated via two approaches: On the one hand participants were asked to compare the average effective dose received during CT scan of Abdomen pelvic and Radiography Skull examinations which have been evaluated at  $D_{AP}^{CT} \sim 11$  mSv and  $D_{SC}^R = 0,07$  mSv respectively [25]. On the other hand, evaluate the average effective dose received during CT scan of Abdomen pelvic examination. The fourth section dealt with the prescribers' knowledge of the risk of cancer induction after one CT scan of Abdomen pelvic examination. Also, we asked

doctors if they had received training with regard to radiation protection. Each question had at least three multiple choice answers with one correct answer, except the questions of the first and the fourth main areas were dichotomous (i.e. yes/no).

## 3. RESULTS AND DISCUSSION

### 3.1 The Study Population

A total of 153 questionnaires were completed out of 260 administered (59%). There were 93 men and 60 women (sex ratio 1.55). The average professional-experience of respondents was  $11,76 \pm 2,43$  years with 58% among them having more than 10 years' experience. Among 153 participants, 37% were Medical Specialists, 31% General practitioners, 23% Surgeons, and 9% Residents.

### 3.2 Current Prescribers' Practice Regarding CT Examinations

The question aimed at the prescription of CT for patients. 95% of the practitioners' responders indicated that they prescribe CT examinations for patients during their exercises. Concerning the use of a guideline, the doctors were asked to prescribe less irradiating exam. 90% of physicians do not use the guideline during CT prescriptions. About 38% of prescribers indicate always, 48% sometimes and 12% never when asked whether they take into account the benefit/risk ratio related to x-rays during CT scan prescription. Regarding the take into account the benefit/risk ratio of x-rays during the prescription of a CT scan physicians answers can be summarized as follows:

- Always by 34% of Surgeons, 43% of Medical specialists, 40% of the General practitioners and 14% for Residents.
- Sometimes by 46% of Surgeons, 38% of Medical Specialists, 48% of General practitioners and 86 % for Residents.
- Never by 17% of Surgeons, 16% of Medical Specialists, 8% of the General practitioners and 0 % for Residents.

About the explanation to the patients of the risk related to x-rays and the ratio benefit/risk during CT scan prescriptions, only 10% of prescribers indicate always, 57% sometimes, 30% never and 3% have not reported any response.

The answers of Medical referring concerning explanation to the patients of the risks associated with x-rays and report benefit/risk that resulted during the prescription of a CT scan can be summarized as follows:

- Always by 4% of Surgeons, 7% of Medical specialists, 19% of the General practitioners and 0 % for Residents.
- Sometimes by 57% of Surgeons, 46% of Medical Specialists, 60% of General practitioners and 86% for Residents.
- Never by 37% of Surgeons, 43% of Medical Specialists, 17% of the General practitioners and 7% for Residents.

### 3.3 Knowledge of Doses and Health Risks Related to Radiation by Doctors

Firstly, participants were asked to give an estimation of the average dose received by patient during CT scan of abdomen pelvic compared to the dose of a standard chest x-ray radiograph in an adult ( $D_{SC}^R = 0.07$  mSv). A total of 18% answered correctly ( $7 < D_{AP}^{CT} \leq 11$  mSv), while 46% underestimated it, 11% overestimated it, and 25% had any idea about the dose received during CT Scan of Abdomen pelvic examination (Table 1). Moreover, the rate of any idea equivalent to the group Residents, General practitioners, Medical specialists and Surgeons is the 64%, 31%, 23% and 9% respectively.

**Table 1. Assessment of the average dose of abdomen pelvic CT scan comparatively to an adult standard chest radiograph**

Direction of the answers	N	%
Underestimation	70	46
Correct answer	28	18
Overestimation	17	11
n. a	38	25
Total	153	100

\* n.a., no answer

The second question assessed the dose equivalents of pelvic abdominal scanner in comparison to a yearly natural radiation exposure in Morocco. Taking into consideration that the yearly natural radiation exposure in Morocco is about 2.5 mSv, how you estimated the average dose delivered during a pelvic abdominal CT scan? A total of 10 % answered correctly ( $D_{AP}^{CT} = 11$  mSv), while 56% underestimated, 9% overestimated and 25% had any idea about the radiation due to CT Scan of abdomen pelvic examination (Table 2).

Moreover, the rate of any idea equivalent to the group Residents, General practitioners, Medical specialists and Surgeons is the 64%, 31%, 23% and 9% respectively.

**Table 2. Assessment of the average dose of abdomen pelvic CT scan comparatively to a yearly natural radiation exposure in Morocco**

Direction of the answers	N	%
Underestimation	86	56
Correct answer	15	10
Overestimation	14	9
n. a	38	25
Total	153	100

\* n.a., no answer

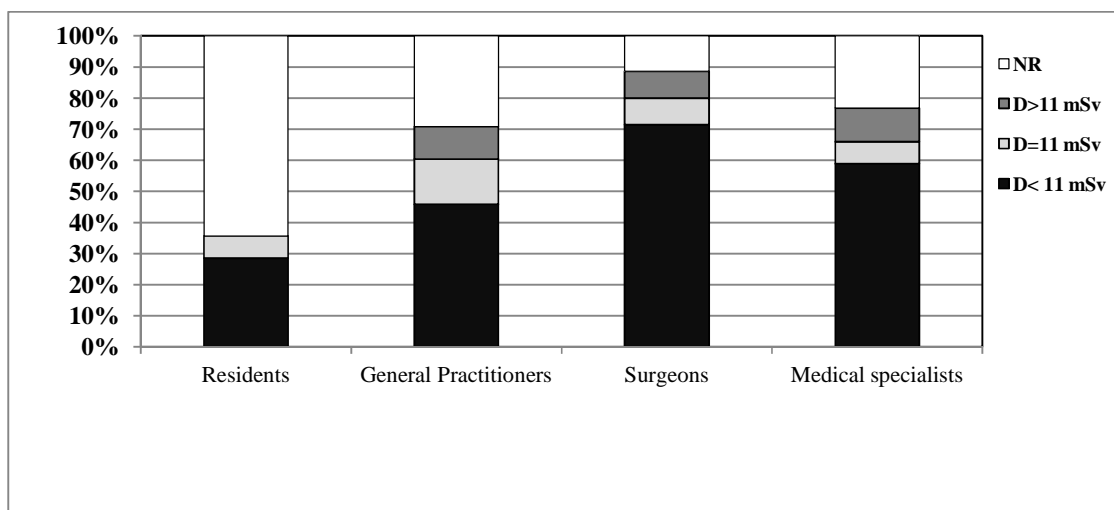
The underestimation of the dose received by the patient during a CT scan of abdominal pelvic examination was made by 71% of Surgeons, 59% of Medical specialists, 46% of the General practitioners and 29 % for Residents. The correct estimation was reported by 9% of surgeons, 7% of Medical Specialists, 15% of General practitioners and 7% for Residents. The overestimation was answered by 11% of Surgeons, 9% of Medical Specialists, 10% of the General practitioners and 0 % for Residents (Fig. 1).

The question assessed the physicians' knowledge on the lifetime risk for the development of cancer after one abdomen pelvic CT examination. This very specific epidemiological topic was answered correctly by only 36% (approx. 1 cancer death per 1,000) [26,27], whereas 63% didn't have the correct answer and 1% did not respond.

### 3.4 Further Education and Training

The final question was about the physicians' knowledge on the education for Residents and training for Physicians in radiation protection of patients:

- Only 11% of Medical Specialists and 3% of Surgeons have accomplished continuing training programs during their professional practices.
- 95% of Surgeons, all Medical Specialists and General Partitions reported having never been trained on radiation risk.
- All Residents have responded they have not accomplished any academic training in radiation protection of patients at the university.



**Fig. 1. Percentage distribution of medical specialties responds to evaluate the average dose of abdomen pelvic CT scan**

### 3.5 Discussion

This study aims at evaluating the current physician's practices regarding the CT scan prescriptions in Moroccan hospitals. Moreover, knowledge on radiation doses and risks was explored. Our study proved that Physicians' knowledge about radiation exposure from medical imaging is insufficient therefore they would at inform their patients of the risks of radiation exposure. Generally, these doctors underestimated radiation exposure of frequently used diagnostic imaging and the associated risks. This under-estimation of doses may lead doctors to requesting more diagnostic imaging than they would if they had accurate knowledge. It is likely that various factors contributed to the insufficient knowledge scores achieved in this study.

Only 10% of physicians of this study used a guideline during prescriptions of CT exam. Yet the European directive on the radiation protection for medical purposes requires justification of the radiological procedure which is one of the steps necessary to obtain the radiation protection of patients as part of a quality assurance process [28]. The lack of use of referral guidelines could be explained by the Moroccan radiologists by the absence of national protocols [24].

38% of prescribers in our study group take account the benefit/ risk ratio. This result is much lower than 70% reported by Gervaise and all

(2011) in a similar study for a population of French hospital doctors [25].

Just 10% of physicians group have explained the x-ray risk to the patients during prescription. This result is much lower than 22% reported by Lee and all (2004) in a similar study for a population of emergency physicians in the United States of America [22] and less than 25% reported by Gervaise and all (2011) in a similar study for a population of French hospital doctors [25].

The knowledge on radiation doses in our study group is limited. In detail, we asked to compare the average effective dose received during an abdomen pelvic CT scan in adults to a standard chest radiograph. Only 18% of the study participants answered correctly. This result is lower than 30% reported by Lee and all. 2004 in a similar study for a population of emergency physicians in the US [29] and less than 32,5 % obtained by Merzenich and all. 2012 in a similar study in German [30]. It is over than 13 % reported by Gervaise and all 2011 in a similar study for a population of French hospital doctors [25].

Furthermore, 46% of doctors generally tend to underestimate the radiation exposure due to an abdomen pelvic CT scan for adults. This result is in agreement with that reported by Krille and all. 2010 in a published systematic review on physicians' knowledge regarding radiation

dosages and risks due to computed tomography [31].

The physicians' knowledge on the lifetime risk for the development of cancer after one abdomen pelvic CT examination was answered correctly by only 36% (approx.1 cancer death per 1,000 deaths) [26,27] of responses in our study group. This result is higher than 12,5% reported by Jacob and all. 2004 for a population of hospital doctors [32]. It is approximately the same as 31% obtained by Rice et al. [33] for a population of paediatrics surgeons. It is lower than 39% reported by Gervaise and all. 2011 in a similar study for a population of French hospital doctors [25].

The results obtained in this study could be explained by many factors. About 95% of the doctors reported never had a formal training on patients' radiation protection. This reflects a poor knowledge of the principles of radiation protection by our clinicians. This result is higher than 75 % reported by Gerben and all 2010 for a physician population of the Australian emergency departments [34], and 34% reported by Gervaise and all. 2011 in a similar study for a population of French hospital doctors [25].

Our study group comprised 9% of junior doctors, and especially interns. All intern's responded have not benefited from any academic training in radiation protection of patients during their university curriculum. In practice, the junior doctors need to discuss the need for CT imaging with a senior doctor before its prescript. We recommend education and ongoing assessment during the intern year to improve understanding of radiation exposure.

#### 4. CONCLUSION

Medical specialists, General practitioners, Surgeons and Residents' knowledge and practices concerning radiation exposure related to radiological imaging are weak and these results are comparable to those found in other countries studies. Physician groups in our sample had a varied knowledge of the risks and doses from radiation exposure, but their performance was not good. Also, there is no communication about risk between the doctors and the patients.

So, we recommend to develop educational programs at the universities and also continuing training programs for all doctors from all

specialties with the aim to improve their understanding of medical radiation exposure. There is also a need for establishing collaboration between radiologists and the other medical specialists in order to create Moroccan radiology protocols. We also propose that radiation doses and associated risks should be provided on imaging request forms. We suggest connecting all radiological structures with a national database that stores all information relating to the prescription and the realization of all radiological procedures. This would enable the prescribing physician to review patient's radiological record and to discuss with him the eventual risks which will allow to and choose the adequate radiological examination.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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