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A Report on Occupational Ionizing Radiation Exposure by an Orthopedic Surgeon in a National Health-care Setting - Clinical Case Perspective

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Learning Point for the Article:

Occupational ionizing radiation exposure monitoring for health care workers is recommended to confirm compliance with annual dose limit.

Abstract

Introduction: The purpose of the study was to have a general overview of the current understanding of occupational ionizing radiation exposure among health care workers and to explore the potential risks of such exposure to orthopedic surgeons working in national health-care setting.

Methods: The author conducted 4 months measurement of ionizing radiation exposure using body and finger dosimeter. The result used to estimate the annual occupational ionizing radiation exposure. The final results compared to previously published data with general exploration of the risk associated with such exposure through literature review.

Results: The results indicate that the current exposure is below that of the dose limit set by the International Commission on Radiological Protection (ICRP) and found to be similar to previously published data.

Conclusion: Health-care employees are the largest group exposed to ionizing radiation [1, 2]. The carcinogenic effect of high dose of radiation on humans is well documented [1, 2], but the long-term effect of exposure to low doses of ionizing radiation is not clear. Some published studies indicate increased risk of cancer among female orthopedic surgeon which may or may not be directly linked to ionizing radiation exposure. We should reinforce the main principles recommended by the ICRP: Justification, optimization of protection, and dose limitation.

Keywords: Ionizing radiation, occupational exposure, orthopedic surgeon, healthcare.

Introduction

Health-care employees are the largest group exposed to ionizing radiation [1, 2]. The carcinogenic effect of high dose of radiation on humans is well documented [1, 2], but the long-term effect of exposure to low doses of ionizing radiation is not clear.

Ionizing radiation has two types of harmful effects on human tissue. The deterministic effect can be avoided when the dose is kept below the tissue-specific threshold for that particular effect [3]. However, the stochastic effect can cause cancer after a latent period that can vary from years to decades [3].

The International Commission on Radiological Protection (ICRP) has been involved in advising about radiation hazards since 1928 [3]. The ICRP also recommends radiation dose limits for both the public and workers [4] (Table 1). What is more, our current definition of occupational and public ionizing radiation exposure, as well as the definition of the stochastic and deterministic effect of radiation, is produced by the ICRP (Table 2). The ICRP also promotes three fundamental radiological principles: Justification, optimization of protection, and dose limitation [4]. In the National Health Service (NHS), it is mandatory to undergo training in the safe use of ionizing radiation. However, staff exposure is not well

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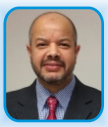

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Type of limit	Occupational, mSv in a year	Public, mSv in a year
Effective dose	20, averaged over 5 years, with no more than 50 mSv in any 1 year	1 (exceptionally, a higher value of effective dose could be allowed in a year provided that the average over 5 years does not exceed 1 mSv in a year)
Equivalent dose to lens of the eye	150	15
Equivalent dose to skin	500	50
Equivalent dose to hands and feet	500	-

ICRP: International Commission on Radiological Protection, mSv: Millisieverts

Table 1: Dose limit as recommended by ICRP

Occupational exposure	Public exposure	Stochastic effects of radiation	Deterministic effects of radiation
This refers to all exposure incurred by workers in the course of their work, with the exception of 1. Excludes exposure and exposures from exempt activities involving radiation or exempt sources; 2. Any medical exposure; and 3. The normal natural background radiation.	Exposure incurred by members of the public from radiation sources, excluding any occupational or medical exposure and the normal local natural background radiation.	Malignant disease and heritable effects for which the probability of an effect occurring, but not its severity, is regarded as a function of dose without threshold.	Injury in populations of cells, characterized by a threshold dose and an increase in the severity of the reaction as the dose is increased further.

ICRP: International Commission on Radiological Protection

Table 2: Definition as per ICRP 103

monitored in some areas. Orthopedic surgeons and trainees, in particular, do not carry personal dosimeters to track their individual exposure, even though they are required to the use of safety equipment including lead gowns and thyroid shields that are always available in orthopedic and trauma theaters. Large numbers of orthopedic procedures require the use of image intensifiers including fracture manipulation and fixation and joint injections. The number of cases needing the use of ionized radiation varies among orthopedic surgeons, depending largely on their sub specialities and workload [5].

Materials and Methods

The author performs trauma and orthopedic procedures in an NHS facility in the UK. The author used dosimeters over a 4-month period, one worn over the chest area and one finger dosimeter in each hand. Dosimeters were changed every 2 months. During the trial period, the author performed in total of 82 procedures requiring the use of image intensifiers. Table 3 summarizes examples of procedures performed during the trial period. Table 4 summarizes the workload during the same period. Dose area product (DAP) and screening time are obtained directly from the image intensifier machine. Analysis of the dosimeter and the collected data were carried out after the completion of the trial period.

Results

The estimated annual dose in millisieverts is calculated by obtaining the total dose over the 4-month trial and multiplying it by three (Table 4).

There is a large range in DAP values, varying from 0.08 to 70 centigray-centimeters squared. This indicates that the use of fluoroscopy varies significantly between the different procedures. Hence, the dose per procedure would be expected to vary depending on the case mix. Theoretically, the DAP should give the best indicator of likely operator dose because the scattered radiation is strongly linked to both incident dose and area of the beam. The monitoring indicates that doses are currently below the "others" category, which includes members of the public (Table 1). The dose is currently relative well controlled, so no further measures are required. However, monitoring should be reviewed at suitable intervals, when workloads or members of staff change or if procedures change.

Discussion

Those who are employed in health facilities represent the largest group of individuals exposed occupationally to artificial radiation sources [1, 2]. Medical surveillance is only required for classified radiation workers in the UK (i.e., those who may exceed three-tenths of a relevant dose limit during a calendar year).

Literature indicated that there is a lack of understanding among health-care professional about the stochastic and deterministic effects of ionizing radiation exposure [6, 7, 8, 9, 10]. This worrisome trend seems to occur in both developing and developed countries. There is emphasis on mandatory training and use of protective measures; however, there also seems to be a casual attitude toward ionizing radiation risk because its effect is not instantaneous and not visible.

Some studies indicate that the use of mini-C arm fluoroscopy can significantly reduce ionizing radiation exposure compared to that of conventional C-arm [11]. However, the use of mini-c arm is limited due to its size to procedures mainly of the wrist

Procedure	Total time of XR exposure (min)	Total dose of XR exposure cGycm² (DAP)
Open fixation of distal radius fracture	0.17	2.69
Open fixation of patella fracture	0.17	9.13
Open fixation of scaphoid fracture	0.55	6.8
Intramedullary nailing of tibia	2.12	16.2
Intramedullary nailing of humerus	1.18	42.1
Steroid injection thumb joint	0.02	0.08
Steroid injection hip joint	0.09	23

DAP: Dose area product, cGycm²: Centigray-centimeters squared

Table 3: Examples of surgical procedures carried out by the author

Position	Results mSv	Results mSv	Estimated annual dose of the author mSv (total dose January–April ×3)
	January/February	March/April	
Finger 1	0.65	0.53 (L)	3.5
Finger 2	0.46	0.55 (R)	3
Body	0.12	0.1	0.7

mSv: Millisieverts

Table 4: Workload over 4-month period

and hand.

The risk to the eye of orthopedic surgeon due to ionizing radiation exposure is less charted territory. Certainly using protective lead eye wear is not a common practice among orthopedic surgeons practicing in the NHS. Some studies indicated that the heavy workload can reach the annual estimated dose to the lens and sometimes can exceed this level, so the use of protective lead glasses is recommended [12, 13].

Some publications have indicated that increased patient body mass index (BMI) increases a surgical team's occupational exposure to ionizing radiation [14, 15]. Because we are seeing a current influx of large numbers of patients requiring surgery who have high BMIs, this factor must be taken into consideration. This might be an indication for regular monitoring of occupational radiation exposure for surgeons who deal with obese patients.

It is well known that acute exposure to high levels of ionizing radiation carries carcinogenesis effects [1, 2]. However, the long-term effect of exposure to very low levels of ionizing radiation is less established. In particular, exposure among medical professional is not extensively studied. Two published studies [16, 17] identified an increase of breast cancer among female orthopedic surgeons compared to the general United States population. In other studies [18, 19], there is evidence of increased prevalence of cancer among orthopedic female surgeons, which may or may not be directly linked to ionizing radiation exposure. As per ICRP 2007, the cancer estimate due to low dose of radiation is 5.5×10−2 per sievert [4].

Conclusion

Our monitoring results seem similar to previously published figures in the literature [3, 20, 21]. Even though it is reassuring that the figures indicate the occupational exposure is currently below that of the dose limit set by the ICRP, this situation should not promote a culture of complacency when it comes to ionizing radiation. We should promote the culture of the main three principles recommended by the ICRP [4]: Justification, optimization of protection, and dose limitation.

Clinical Message

Occupational ionizing radiation exposure among health care worker can cause harmful effect on health. Monitoring of occupational ionizing radiation is recommended to establish the annual exposure dose and determine that it is within the recommended level based on the recommendation by ICRP.

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Consent: The authors confirm that Informed consent of the patient is taken for publication of this case report

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