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Comparison of Radiation Exposure in the Practice of Anesthesia in Orthopedic Operating Theaters

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Aim: The doses received by anesthesiologists and technicians from x-ray devices used in orthopedic operating theaters were measured and calculated in compliance with international standards.
Methodology: Ten personal thermoluminescence dosimeters were given to ten anesthesia operators and they wore the TLD dosimeters for 60 days. The TLD dosimeters were read by the Turkish Atomic Energy Agency.
Results: The measured doses of ionizing radiation received by anesthesiologists and technicians were found to be 0.07 – 0.18 mSv over two months and the calculated doses were found as 0.63-1.26 mSv per two month. The absorbed doses from ionizing radiation were found to be within the safe limits. However the calculated dose values in the scattered field were found to be important for medical staff.
Conclusion: The surgical team should keep away from the radiation exposure as much as possible. They should always wear the lead vest.

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Keywords: Anesthesia operators; orthopedic operating theaters; ionizing radiation dose.

1. INTRODUCTION

Due to the increased use of ionizing radiation in diagnosis and treatment health care workers (HCWs) exposed to radiation are at risk. Although there is literature stating that the amount of ionizing radiation anesthesia operators are exposed to falls within safe limits (<2 mSv/month), changes in working conditions and the increasing use of radiation devices in operating theaters increase the risks of dangerous exposure. There is no specific threshold dose value for stochastic effects. As known, the probability of damage increases as the radiation dose increases.

There are various studies measuring the radiation dose absorbed by anesthesia operators using various technique and standard radiation detectors [1-5]. Radiological procedures are frequently carried out in the operating theaters of the orthopedics, urology and brain clinics at the Ankara Numune Education and Research Hospital (ANEAH). In general, operating nurses, anesthesia technicians and anesthesiologists as well as surgeons work continuously in these operating theaters. The aim of this study is to determine the x-ray dose that anesthesia technicians and anesthesiologists are exposed to when working in orthopedic operating theaters. To determine the doses, the thermoluminescence dosimeters (TLD-100) were used and also the dose values were calculated by considering NCRP [6]. The experimental results were compared with the calculated values, the international standards and the values found by other researchers.

2. MATERIALS AND METHODS

The persons included in these studies were anesthesiologists and anesthesia technicians working in the orthopedic operating theaters. Extra protection except the standard lead apron was not provided for participants while the radiation sources were working. The TLDs (TLD-100) (1 mm × 1 mm) were worn by five anesthesia technicians and five anesthesiologists for two months. The TLDs were placed on the lead apron. That is, the measured doses are for the remaining parts of the body other than lead apron (thyroid, eye lens, hands). At the end of this two-month period the TLDs were sent to Turkish Atomic Energy Agency (TAEK) to be read. TAEK is the responsible for radiation measurements in Turkey. The routine personal dose measurements using TLD procedure was applied by TAEK.

In the operating theaters C-hand scopes (Ziehm 8000 C) devices were used by the staff. This device is the only source of radiation exposure. Its x- ray tube voltage is 125 kV_p and the maximum tube current is 200 mA. Although the position and orientation of the operators were not stable the distance from patient or tube was accepted about 1 m in dose calculations. Fig. 1 shows the geometric description of the orthopedic room.

Surgical procedures began at 8.00 am and continued until 4.00 pm in every theater. One anesthesia technician and one anesthesiologist worked together for approximately four hours/day. X-rays bursts were repeated several times due to incorrect or incomplete shots. Thus, both the number of x-ray bursts and the duration were different for every operation. A total of 880 operations took place in those operating theaters over one month (Table 1).

The plan for this study was approved by the scientific ethics committee of ANEAH at February 2011.

The radiation dose values received by anesthesiologists and technicians were theoretically calculated by taking into account the NCRP Report 147. The personnel in the operating theaters are exposed to a scattering dose. The scattering dose, D_S, represents a part of primer dose, D_P, received by the patient. As the number of operations in each theater varies the doses were calculated individually for each theater.

3. RESULTS AND DISCUSSION

3.1 Measured Doses

In this study the dose of ionizing radiation received by anesthesiologists and technicians was experimentally found to be 0.09 – 0.18 mSv over two months (Table 1). Dose values ≤ 0.10 mSv over two months were stated by TAEK as being a low dose. Low dose means that dose is below the limit value adopted by ICRP. The allowed dose limit by the International Commission on Radiological Protection [7] is about < 2 mSv per a month. The dose ranges

Table 1. Results of scattered dose values carried out on anesthesiologists and anesthesia technicians

	TLD no	Room no	Total number of event two months	Calculated dose (mSv)	Experimental dose (mSv)
Anesthetists	1	11	160	0.84	0.12±0.02
	3	14	200	1.050	0.18±0.02
	5	15	120	0.63	0.07±0.02
	7	16	240	1.26	0.14±0.02
	9	17	160	0.84	0.12±0.02
Anesthesia technicians	2	11	160	0.84	0.11±0.02
	4	14	200	1.050	0.15±0.02
	6	15	120	0.63	0.10±0.02
	8	16	240	1.26	0.12±0.02
	10	17	160	0.84	0.09±0.02

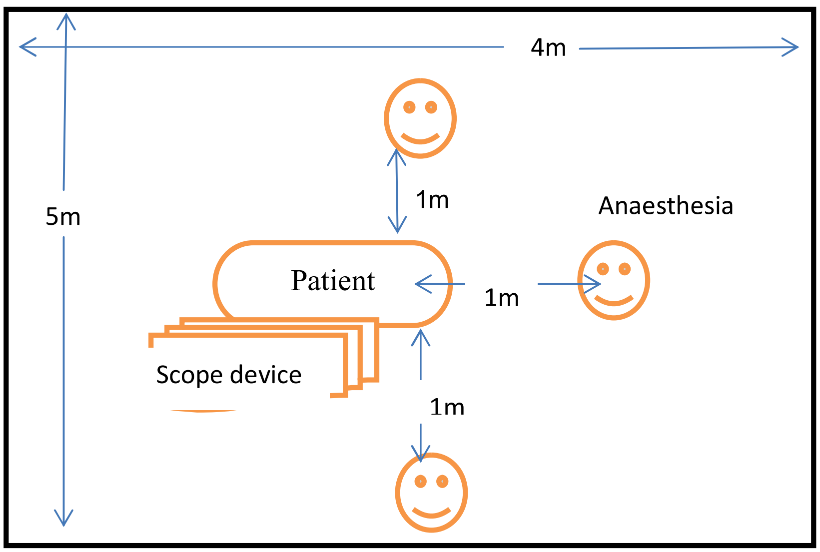

Fig. 1. Geometric description of the orthepedic operations

experimentally recorded in this study fall within acceptable limits such as those advised by the ICRP.

The annual dose limits in accordance with international standards were announced by the TAEK in Turkey. For example, the effective dose equivalent for radiation workers is 50 mSv ⁄year and the mean value over five successive years should not be greater than 20 mSv ⁄y; the limit for the annual dose equivalent for the skin on the hand or foot is 500 mSv and for the eye lens it is 150 mSv [8,9]

3.2 Calculated Doses

It was assumed that the anesthesia technicians and anesthesiologists were standing about one meter from x-ray tube and from the patient. At 125 kV_P, Dose × (unit workload)$^{-1}$ = 7.17 mGy/mA.min. The utilization factor is U=0.25 and the occupancy factor is T=1 (These values were taken from the presentation by Douglas, [10]; the distance from tube is about 1 m.

The example was given for room No: 14:

The workload per week for 25 operations is, $25\times3\times60^{-1}$ min × 200 mA=250 mA.min×week^{-1}. It was assumed that the x-ray tube was used 30 times for each operation. Therefore, Dose= 7.17×250=1792.5 mGy×week^{-1} and D_P= 1792.5×0.25×1⁄1 = 448.125 mGy×week^{-1}. The scatter fraction is assumed 0.0025; the size of standard operating theater is 400 m^2 (from NCRP data) and the real size is 30m^2. Therefore, D_S =448.125×0.0025×30 × (400×0.8×0.8)$^{-1}$= 0.13

mGy×week^{-1}; D_S= 1.050 mGy per two month. The quality factor is 1 for x-rays and so 1.050 mGyper two month = 1.050 mSv per two month.

For room No: 11:

160 operation/ two month= 80 operation/ month= 20 operation/ week. The workload per week for 20 operations is, 20×3×60^{-1} min×200 mA=200 mA.min×week^{-1}. It was assumed that the x-ray tube was used 30 times for each operation. Therefore, Dose = 7.17×200=1434 mGy×week^{-1} and D_P= 1434×0.25×1⁄1 = 358.5 mGy×week^{-1}. The scatter fraction is assumed 0.0025; the size of standard operating theater is 400 m^2 (from NCRP data) and the real size is 30 m^2. Therefore, D_S= 448.125×0.0025×30 × (400×0.8×0.8)$^{-1}$ = 0.10 5 mGy×week^{-1}; D_S= 0.84mGy per two month. The quality factor is 1 for x-rays and so 0.84 mGy per two month = 0.84 mSv per two month. These procedures were applied to each operation theater and the results were given in Table 1.

As seen from Table 1, the calculated dose values are higher than those of the experimental dose. For example, while the experimental dose value for room No 11 is 0.12 mSv the calculated value is 0.84 mSv. The calculated value is approximately higher seven times than other. The relative large dose value was found to room No 16 for both experimental and theoretical. The reason of this is the TLD, No 7 and 8 are put on the operating surgeons. The experimental dose ranges found in this study fall within acceptable limits but the calculated results not. It is important to note that the calculated dose values are not equal to the absorbed dose by the workers but they can be the maximum doses absorbed by them.

Various studies have been reported the similar results. Some results reported for anesthesiologists in orthopedic operating theaters are as follows:

Noordeen [8] 1.25-3.95 mSv/month ≈0.32 mSv/week

Muller et al. [9] 1.27- 1.19 mSv/year ≈ 0.024 mSv/week

Durach et al. [11] 20 mSv/year≤0.38 mSv/week

Ismail et al. [12] <20 mSv/year≤0.038 mSv/week

Ho et al. [13] 0.20 mSv/year≈0.0038 mSv/week

This study (measured) 0.07-0.18 mSv per two month≈ 0.009-0.0225 mSv ⁄ week

This study (calculated) 0.63-1.26 mSv per two month≈ 0.078-0.16 mSv ⁄ week

The difference between the minimum experimental dose value (0.009 mSv ⁄ week) and the minimum calculated value (0.63 mSv ⁄ week) was found too big. The main reason of this is that the distance between x-ray tube and the staff can vary, and so the exposure time can vary; it is important that the device should record the exposure time. It was found that the absorbed dose from ionizing radiation falls within the safe limits as reported by ICRP. It is also well known that these devices are used multiple times during procedures because of incorrect or faulty shots. The amount of time that anesthesiologists and technicians spend in the theater can vary depending on the surgery conditions. The operation's duration may be extended over some days and so the use of radiation devices also increases. All of these can explain the reason for the calculated values being higher. The results showed that the experimental dose values absorbed by an anesthesiologist were seven times lower than the theoretically calculated dose values.

4. CONCLUSION

In this study, it was found that the absorbed dose from ionizing radiation falls within the safe limits. However, the calculated doses values in the scattered field were found to be important in the context of protecting the medical staff from radiation. Although they are mainly exposed to scattered radiation coming from the patient, part of the exposure may also come from the x-ray tube.

There is a lot of information about some negative effects of long-term exposure of low doses ionizing radiation. Therefore, the surgical team should keep away from the radiation source as much as possible.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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