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Estimation of Radiation Dose Exposure in the Treatment of Proximal Femur Fractures

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1. Introduction

Fluoroscopy makes a crucial role in orthopedic surgeries by providing a better assessment of the operated anatomical structures and the implanted synthesis material, besides to reducing the surgical time and morbidity of patients [1]. Among the post-traumatic bone surgery procedures, those for osteosynthesis of a proximal femoral fracture are associated with the most significant exposures due to the intraoperative use of fluoroscopy, especially to ensure successful bone reduction, stabilization and allow minimally invasive procedures to be performed [2].
Despite the benefits generated, such procedures expose the medical team to the risks of ionizing radiation. When interacting with biological tissues, this type of radiation can induce cell damage, able of causing stochastic effects, those for which there is no dose threshold, or deterministic, which configure effects dependent on the radiation dose received. Therefore, exposure to ionizing radiation may be associated with the induction of cataract, skin and thyroid carcinomas, leukemia and sterility [3].
In that regard, taking into account the large number of surgical interventions for the treatment of femur proximal fractures, made possible by fluoroscopic guidance, and the risks related to exposure of surgeons to ionizing radiation, this study is proposed, whose objective is to monitor radiation doses received by the orthopedic surgical team in the aforementioned procedures, in order to propose measures to optimize the radiological protection of these professionals.

2. Methodology

This study was carried out in a catholic hospital of medium complexity in Brazil. A total of 18 surgical procedures for fractures of the proximal femur were monitored, these was categorized with the AO classification of trochanteric region fractures, allocated on the form of simple (31-A1, 15%), multifragmentary (31-A2, 71%) and reverse obliquity (31-A3, 14%). The procedures were performed on three models of equipment, with respective operating modes: Siemens Cios Select (continuous fluoroscopy), GE OEC Brivo (low dose fluoroscopy) and GE Fluorostar (continuous fluoroscopy). For each procedure, the fluoroscopy time, kerma area product (P_{KA}), reference point kerma ($K_{a,\,r}$) and exposure parameters (tube peak voltage (KVp) and tube current (mA)) were registered. The radiation dose to the ocular lenses and hands was estimated by measuring the air kerma at the entrance surface with a thermoluminescent dosimeter LiF: Mg; Ti (TLD-100), previously calibrated at the Laboratory of Ionizing Radiation Metrology - DEN / UFPE. Two dosimeters were encapsulated in a plastic badge and attached to the staff medical face: side the left eye, the glabella and side the right eye. A Harshaw ring badge containing only one dosimeter on the ring finger of the right and left hands was used for extremity monitoring. The reader of response luminescent used was a Victoreen model 2800, in step mode and heat rate of 10 ^{0}C /s.

3. Results and Discussion

Of the 18 procedures monitored, 10 were performed with the Siemens Cios Select equipament, 5 with the GE FluoroStar and 3 with the GE Brivo. Figure 1 shows the distribution of $K_{a,\,r}$ and P_{KA} values for each of the three types of equipments used during the monitoring of proximal femur fracture procedures. The data indicate that the highest P_{KA} and $K_{a,r}$ values were obtained with the GE FluoroStar equipment, which provided an average $K_{a,r}$ value of 43.7 mGy, with a maximum of 87.4 mGy and an average P_{KA} value of 5.4 Gy.cm^2 , with a maximum of 10.6 Gy.cm^2.

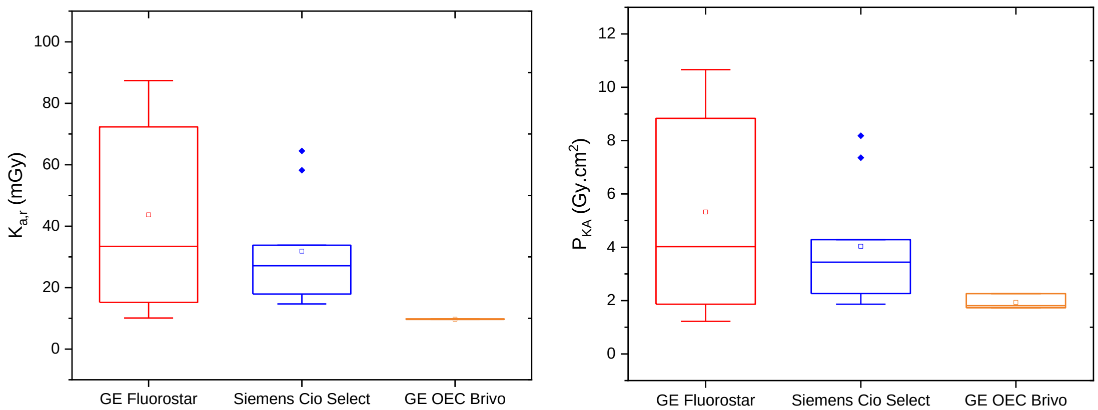

Figure 1: Distribution of $K_{a,\,r}$ and P_{KA} values for the three models of equipment during surgeries proximal femur fractures.

The values of Hp(d) in the regions of the eyes and hands of the operator are shown in Table I, where the mean and maximum values divided by equipment in the 18 surgical procedures of proximal femur fracture are shown.

Table I: Average and maximum values of Hp(d) per equipment in various regions of the main and assistant operator.

Equipament	Region		Main Operator	Assistant Operator
Siemens Cios Select (n=10)	Hp(3) (µSv)	Right Eye	44,7 (10,8 – 103,3)	29,0 (7,0 – 56,8)
		Glabella	40,2 (15,9 – 79,1)	34,1 (12,4 – 65,2)
		Left Eye	32,6 (7,4 – 80,5)	29,3 (1,9 – 53,6)
	Hp(0,07) (µSv)	Right hand	208,5 (37,3 – 327,5)	136,2 (38,0 – 312,6)
		Left hand	256,9 (38,6 – 882,8)	86,8 (11,8 – 158,2)
GE FluoroStar (n=5)	Hp(3) (µSv)	Right Eye	24,4 (3,9 – 50,2)	23,3 (9,1 – 65,6)
		Glabella	28,4 (9,5 – 53,8)	21,3 (3,2 – 62,5)
		Left Eye	27,5 (6,9 – 79,8)	21,9 (6,1 – 48,6)
	Hp(0,07) (µSv)	Right hand	77,0 (0,6 – 218,2)	12,6 (1,1 – 21,6)
		Left hand	110,7 (8,2 – 284,8)	13,2 (9,2 – 21,12)
GE OEC Brivo (n=3)	Hp(3) (µSv)	Right Eye	11,9 (8,7 – 15,2)	12,7 (11,3 – 14,5)
		Glabella	14,6 (8,9 – 25,5)	8,6 (6,6 – 11,4)
		Left Eye	10,5 (9,4 – 11,6)	11,8 (5,6 – 15,3)
	Hp(0,07) (µSv)	Right hand	30,5 (24,7 – 40,4)	39,8 (13,8 – 84,2)
		Left hand	42,7 (23,4 – 74,3)	28,0 (10,4 – 51,8)

The values of personal dose equivalent Hp(d) presented in Table I show that the physician's most exposed region, both main and auxiliary during surgical procedures for treatment of femur fractures, was the left side, especially in the region of the hands. This behavior was expected because the doctor, throughout the procedure, keeps his hand close to the direction of the X-ray beam. Furthermore, it is possible to note that the lowest doses are observed when using the GE OEC Brivo equipment, in the low-dose fluoroscopy operating mode. This operating mode has the current value (mA) reduced by 50% when compared to the other two devices evaluated, which implies a significant dose reduction.

The highest mean value of absorbed dose is concentrated in the region of the hands, especially for the Siemens equipment, with 0.23mSv, showing values close to those of SULIEMAN et al., with 0.25mSv. Note also the efficiency in dose reduction for the GE OEC Brivo, obtaining values in the hands that correspond to about 13% of those found in Siemens Cios Select and 30% of the GE Fluorostar. The dose to the forehead in this work represents the values below those regarding the literature [4] for all equipment. These results give valuable highlights, because, despite the low numerical value of procedures, it was an almost identical estimate for the doses in the hands, in which they have relatively high maximums, especially for the left hand, due to the fact that most of the monitored surgeons are right-handed, making the closest proximity to the tube in their auxiliary hand, which is also responsible for fixing the limbs during fluoroscopy acquisitions, so that it can work with your best hand.

4. Conclusions

Although occupational exposure for orthopedic surgeons is within the limits recommended by national and international organizations in radiological protection, medical personnel must remain aware of the risks associated with ionizing radiation in order to keep exposure levels as low as reasonably achievable. Therefore, radioprotection measures such as the adequate use of personal protective equipment, the reduction of fluoroscopy time, the use of low dose rate modes and the use of shorter patient-image receiver distances should be encouraged.

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