RADIATION EXPOSURE TO PAEDIATRIC PATIENTS IN CEREBRAL PROCEDURES

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Abstract

The aim of this study is to estimate the radiation doses received by paediatric patients during interventional neuroradiology procedures performed at a public hospital in the city of Recife, Pernambuco, Brazil. This study was carried out on 15 patients 3 to 15 years old who underwent cerebral angiographies with a Siemens Artis Zee X ray unit with a flat panel detector. Radiation parameters such as tube potential, tube current and fluoroscopy time were collected during each procedure. The total number of runs and images per run, as well as cumulative reference air-kerma ($K_{a,r}$) and air kerma-product values displayed by the system were also documented. The results showed $K_{a,r}$ values ranging from 203 mGy to 796 mGy, with a mean value of 490.8 mGy. The data also show that the average number of frames/series is 23 and the maximum and minimum values are, respectively, 14 and 44. The results of total air kerma - area product obtained in this study showed that for the angiographic procedures, the mean value is 5.3 mGy•m^2, with a range between 1.9 and 8.8 mGy•m^2.

1. INTRODUCTION

Technological advancements and the advantages of the endovascular techniques over conventional surgery have resulted in an increase of paediatric interventional neuroradiology procedures. The introduction of digital subtraction angiography (DSA) techniques has made the treatment of very small malformations possible and has contributed to the rise of interventional neuroradiology in paediatric patients. While the paediatric interventional neuroradiology is a complex procedure due to the small size of the vascular accesses, it has many benefits to the patient, when compared to conventional surgery, such as quicker recovery times. For paediatric patients, this technique is used for diagnosis and treatment of vascular malformations (AVMs), cavernous angiomas, intracranial aneurysms and the vein of Galen malformations [1]; AVM being the leading cause in children. Its recurrence after treatment is more frequent in children than in adults, and prognosis after hemorrhage in children is better than in adults. About 10–20% of newly diagnosed brain AVMs are in children, and patients under 15 years of age constitute 1–2% of all intracranial aneurysms [1].

In spite of the benefits of the interventional procedures, they may result in high doses to the patient due to the long fluoroscopic times and a significant number of angiographic images to visualize and evaluate any vascular pathology. Special considerations are required for the protection of paediatric patients because they are more sensitive to the radiation effects.

The purpose of this work was to estimate the paediatric patient doses received during cerebral procedures performed in Recife, Brazil and to evaluate eye and thyroid doses received by these patients.

2. METHODOLOGY

This study was carried out on 15 patients, 3 to 15 years old, who underwent cerebral angiographies at a large paediatric hospital in Recife, Brazil; 7 being female and 8 male. Two patients - in addition to the angiography - also underwent an embolization neuroradiology procedure, one due to an aneurism and the other one due to a vascular malformation. All studies were performed on a Siemens Artis Zee X ray unit with a flat panel detector. To estimate patient doses, exposure parameters (kVp, mA, exposure time), patient information (gender, height, weight and age), fluoroscopic time, type of protocol used and number of angiographic images were recorded at time of the examination. The values of reference cumulative dose and the air kerma-area product, indicated by the equipment, were also recorded. The patient´s skin dose was also monitored using two TLD-100 chips, sealed in a polyethylene envelope and placed on: the thyroid, left and right eyes, and at the forehead region. The choice of sites for the measurements was made in such a way that they could represent the doses to important parts of the body, such as the lenses of the eyes and the thyroid. The average of the readings of the two TLDs was used to determine the dose in each of the selected points.

3. RESULTS AND DISCUSSION

Table 1 presents the radiation parameters used during the neuroangiograph procedures evaluated in this study.

TABLE 1. MINIMUM, MEAN AND MAXIMUM VALUES OF THE IRRADIATION PARAMETERS USED DURING THE PAEDIATRIC NEUROANGIOGRAPIC PROCEDURES EVALUATED IN THIS STUDY

Parameter	Neuroangiographic procedure	Neuroangiographic + 3D reconstruction procedure
	Mean (min- max)	Mean (min- max)
Tube potential (kV)	73.1 (63-88)	73 (63-88)
Fluoroscopy time (min)	7.2 (1.5-19)	7.2 (1.5-19)
DSA acquisition	10.7 (5-16)	11 (5-16)
Frames	239.5 (85-398)	274.9 (85-545)

The data show that the average number of frames/series is 23 and the maximum and minimum values are, respectively, 14 and 44. The values obtained are comparable with the values reported by Swoboda et al [2] who found 10.7 min for the mean fluoroscopy time (7.4 min-47 min) for a study with 76 paediatric patients undergoing neuroradiology diagnostic procedures in Canada. It is important to observe that in two patients, in addition to the neuroangiograpic procedures, a 3D dimensional reconstruction procedure was done in order to plan the interventional treatment. The 3D reconstruction procedure is used generally when the patient presents a cerebral aneurysm; it requires a higher number of frames per procedure than the neuroangiograpic procedure. The number of frames per procedure used in this study is similar to the values found in the literature for paediatric [2], and adult patients [3].

Figures 1 and 2 show a box-and-whiskers diagram of the total reference cumulative doses and air kerma-product area measured in the all neuroradiological procedures evaluated. In this graph, the rectangle encompasses 50% of the doses measured and it is limited on the upper and lower sides by lines that represent the first and third quartile of the distribution of doses. The length of the lines that extend upwards and downwards from each rectangle show how the 25% highest and the 25% lowest doses are distributed around the median, indicated by a line inside the rectangle. The point indicated inside the rectangle corresponds to the mean dose value. The figures also present the contribution of the fluoroscopy and the DSA in these dose values. The results show that, as expected, the contribution of the fluoroscopy procedures is lower than that of the DSA acquisitions and it is around 8% of the total reference cumulative dose or air kerma-product dose. This is due to the fact that the DSA acquisitions use much higher exposure parameters than fluoroscopy does, and that to visualize and evaluate vascular pathology, a high number of DSA acquisitions was necessary.

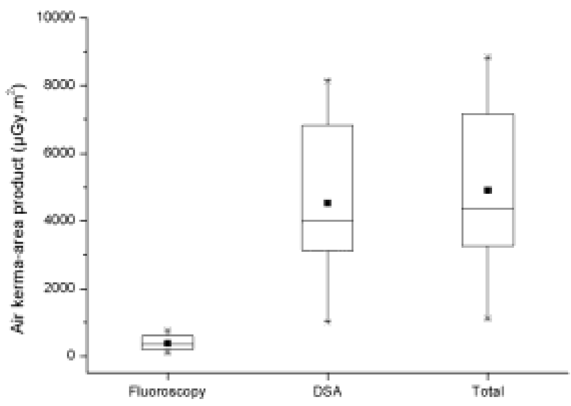

FIG. 1. Air kerma-area product for fluoroscopy, DSA and total neuroangiografic procedure on paediatric patients.

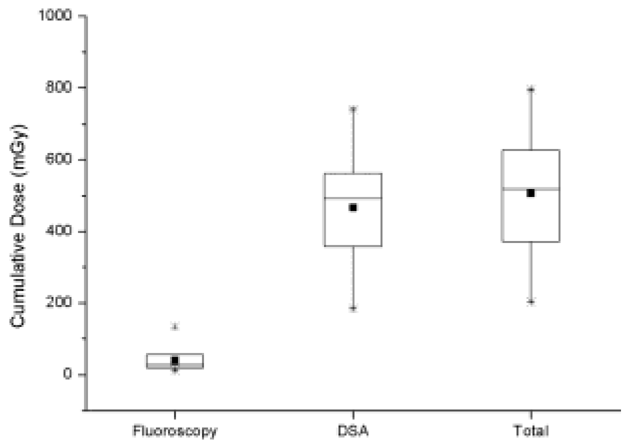

FIG. 2. Reference cumulative dose for fluoroscopy, DSA and total neuroangiografic procedure on paediatric patients.

It can be observed that the dose ranges are wide. This is probably due to patient variation and the complexity of the procedures. The results also show that the air kerma-product value is within the range of 1.9-8.8 mGy•m^2, with a mean value of 5.4 mGy•m^2. These results are similar to those reported by Bor et al. that range from 2 to 17.5 mGy•m^2 with a mean value of 7.48m Gy•m^2.

In Figure 3 the values of the patient skin dose in the region of the eyes, thyroid and forehead are shown. The data indicate that the highest dose was received by the left eye with a mean value of 33.1 mGy and a maximum of 41.7 mGy. The mean dose value on the right eye was 12.3 mGy and the maximum value, 38.9 mGy. The left eye lens doses found in this study are particularly high.

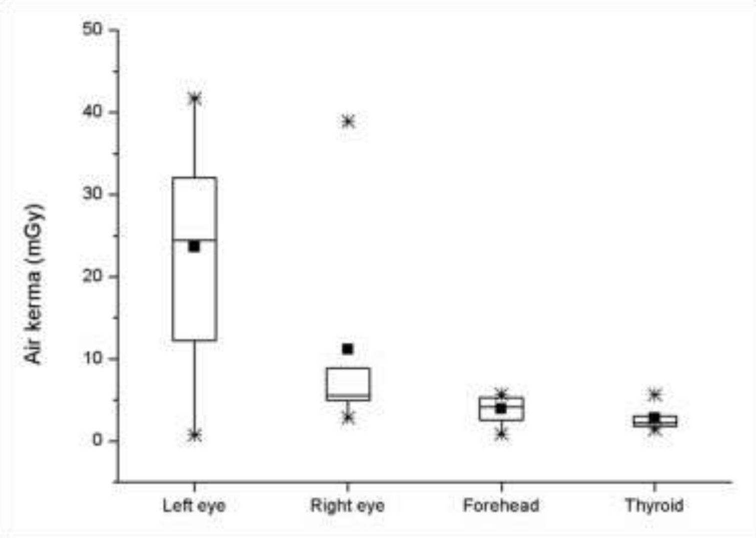

FIG. 3. Distribution of the skin air kerma in the region of left and right eyes, forehead and thyroid measured during neurorangiography of paediatric patients.

4. CONCLUSION

There are few publications on paediatric patient doses in neurointerventional procedures. The doses, especially the eye doses, and the associated risks, are not negligible. The probability of radio-induced lens opacities and cataracts will increase if these paediatric patients undergo other X ray procedures involving the eye lenses during their lifetime. Doses should be recorded in the patient charts for future considerations.

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