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Original Research Article

Brain and Lenses of the Eyes Doses from Head Computed Tomography: A Study of Selected Computed Tomography Centres in Enugu, Enugu State, Southeast and Nigeria

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ABSTRACT

Exposure of the brain and/or eyes to excess radiation could have serious consequences. This study investigated the radiation doses received by the brain and the lenses of the eyes during diagnostic computed tomography (CT) examination of the head.

Lithium Fluoride thermoluminescent dosimeter (TLD 100) chips were used to collect dose data from 32 patients(17males and 15females, age range 3-65years) attending for CT investigations of the head at the CT unit of Memfys Hospital for Neurosurgery, Enugu, Enugu State between July 2012 and January 2013. The absorbed dose to each subject was measured and converted to effective dose using appropriate tissue weighting factors.

In adult patients the mean brain absorbed dose and effective dose were 2.940±1.120mSv and 0.147±0.056mSv respectively. For the eyes, the mean doses were: absorbed dose, 2.947±1.1.113mSv and effective dose, 0.884±0.334mSv. In children, the brain received a mean absorbed dose of 3.918±0.003mSv and a mean effective dose of 0.196±0.001mSv while the lens of the eyes received a mean absorbed dose of 5.600±0.001mSv and a mean effective dose of 1.680±0.001mSv. A weak negative non-significant correlation(r = - 0. 113; P = 0. 231) was noted between dose and age. A weak positive non-significant correlation (r = 0.124; P =0.136) occurred between dose and number of images.

This study revealed that the radiation doses to the brain and the lenses of the eyes were quite low, but it should be noted that dose has a linear relationship with exposure. It is advised that unnecessary scans should be avoided and dose optimized.

Key words: Radiation Dose, Computed Tomography, Lens of eye, Brain, Thermoluminescent Dosimeter.

INTRODUCTION

Radiation is a form of energy which can be both useful and harmful to man. Computed Tomography (CT) is a medical diagnostic procedure that uses x-ray radiation energy. Over the past two decades its use has increased geometrically because of its perceived advantages. Exposure of the brain and/or eyes to excess radiation could have serious consequences. The brain is the centre for memory and intellect and the coordinator of activities and the eyes act as the windows through which individuals interact with the environment. When the heart, brain and eyes are sound an individual will show optimal performance. Injury to these organs could mean a worthless human being.

Exposure of humans to medical radiation is on the increase. Worldwide, the use of computed tomography (CT) is on the increase and the radiation dose to patients from CT investigations is the highest from medical diagnostic exposure. [1-4] Recognizing the increase in the use of radiological procedures, the associated radiation risks and the need for optimization of radiation protection the National Radiation Protection Board (NRPB) in 1997 recommended the documentation of doses to patients during normal procedures. [5]

Although CT of the head accounts for about one-third of all CT scans, [6] only few studies were done to investigate the dose to the brain tissue. It should however, be noted that even though nerve tissues are resistant to radiation, the brain still receives radiation dose which though small, could represent gradual damage to the brain. It is also documented that such typical effective doses of 2mSv from head CT is among those regarded as 'high dose levels' by the International Commission on Radiation Protection (ICRP) and are associated with moderate risks of about 1 in 10,000 or more. [7] Again, the brain is not the only organ irradiated in the course of CT investigation of the head. The lenses of the eyes are also irradiated.

The lenses of the eyes have long been recognized as one of the most radiosensitive organs in the body but information concerning the minimal dose needed to cause cataracts in humans has been scanty. [8] Part of the reason for that is the small dimension and location of the eyes. [9] The threshold dose for cataract formation was however, shown to be very low-especially for children and infants, [10] and irradiation of children's eyes increases the probability of cataract at a younger age than usual. [11] Radiation protection of the lenses is therefore very essential especially for children. In line with the need for radiation protection, the ICRP in 2011 reviewed the dose limit for the lens of the eye from 150mSv to 20mSv per year averaged over a defined period of 5years with no single year exceeding 50mSv. [12]

The first line in the protection of patients is to determine the amount of radiation dose received by patients and then device means of reducing the dose as low as is reasonably achievable without compromising diagnostic quality. Among the methods for reducing dose to patients include avoiding unnecessary scans, [6] and the use of appropriate techniques. [13-17]

Most methods for measuring radiation dose to the brain and lens of the eye used phamptoms and measurements obtained with phamptoms may not truly represent the dose to human organs because of in homogenity of human organs resulting in different scattering pattern from phamptoms. This study aimed at making measurements of the doses received by the brain and lenses of the eye in human beings in a clinical setting.

MATERIALS AND METHODS

A clinical based prospective cross-sectional survey research method was used. Ethical approval was obtained from the management of the CT centre used for the study and informed consent was obtained from the patients that participated in the research. The study was carried out between

July 2012 and January 2013. Dose data was collected for 32 patients using Lithium Fluoride Thermoluminescent dosimeter (TLD-100) chips obtained from the Radiation Safety Adviser (RSA), Nigerian Nuclear Regulatory Authority (NNRA), Abuja, Nigeria. Prior to being used the TLD chips were annealed to 0.00Gy to wipe of previous data on them. The background radiation (BGR) of the diagnostic room was also measured and using a survey meter. The CT machines used were products of General Electric Medical Systems (HiSpeed Nxli and HiSpeed Fx/i) and Ceretom Corporation (Ceretom^{TM} Neurologic) with multiple ring detectors.

For each patient, two TLD chips (labeled FRONT and BACK) were used. With the patient in the position for the investigation and exposure (but before strapping the head to avoid movements) these TLDchips were taped with adhesive tapes respectively on the front of the patient's head at the beam entrance point (glabella) and at the back of the head at the bead exit point (external occipital protuberance). These chips recorded the entrance dose and exit dose respectively during the exposure. Each pair of exposed TLD chips was properly identified with the patient's hospital identification number, age, sex and the exposure parameters. The exposed TLD chips were then read using Harshaw 4500 Dual TLD Reader at the Health Physics section of the Centre for Energy, Research and Training (CERT) of the Ahmadu Bello University, Zaria, Kaduna State.

The TLD peak glow curve values were automatically converted to dose (mSv) using the formula:

Dose = Q x ECC/RCF,

Where Q = charge (glow curve peak value, in nano Coulomb)

ECC = Element correction coefficient = 3749

RCF = Reader calibration factor = 0.0171.

Absorbed dose and Effective dose:

The absorbed dose was computed using the formula:

Absorbed dose = END –(EXD + BGR), where END is the entrance dose (front TLD reading), EXD, the exit dose (back TLD reading) and BGR is the background radiation of the room.

The effective dose to each organ was calculated from the absorbed dose using the formula:

Effective dose, $E = \sum H_T \times W_T = \sum D_T \times W_R \times W_T$

Where H_T is the equivalent dose to each tissue/organ T, and is equal to the product of the absorbed dose D_T (mSv) and the radiation weighting factor W_R. Since W_R for x-rays is unity, the absorbed dose, D_T is numerically equal to the equivalent dose H_T.

Hence $E = \sum$ Absorbed dose x $W_{T.}$ W_T is the tissue weighting factor which characterizes the tissue sensitivity to radiation and hence the radiation risk. In computing the effective dose in the study, the absorbed dose is assumed to each patient is assumed to be uniformly distributed over the head region.

Data analysis:

Dose data was analyzed using Statistical Package for Social Sciences (SPSS) version 15. Both descriptive and inferential statistics were used. The means and standard deviations of the dose were used to express the doses. T-test was used to test the difference in dose between the two groups of patients.

RESULTS

The mean absorbed dose to the adult brain was 2.940 ± 1.120mSv and the mean effective dose to the adult brain was 0.147 ± 0.056mSv (Table 1). For the lens of the eye the mean absorbed dose was 2.947±1.113mSv and the mean effective dose was 0.884 ± 0.334mSv. For both the brain and the lens of the eye, both the mean dose and the mean effective dose were higher in children than in adults (Table 1). In children the mean absorbed doses were 3.918 ± 0,003mSv to the brain and 5.600 ± 0.001 to the lens of the eye while the effective doses were 0.196 ± 0.001mSv to the brain and 1.680 ± 0.001mSv to the lens of the eye (Table 1). Significant difference ($P < 0.05$) exists between the mean dose to the lenses of the eyes in adult and children but no significant difference ($P>0.05$) in the dose to the brain in the two groups. Pearson's correlation analysis revealed a weak, negative non-significant correlation between dose and age($r = -0.106$; P = 0. 301) and a weak, positive non-significant correlation between dose and number of images($r = 0.304$; P =0.002). No correlation was found between dose and sex or between dose and exposure parameters.

Table 1. Mean absorbed dose and mean effective dose to the brain and lens of eye.

	Mean absorbed dose ±SD(mSv)		Mean effective dose ±SD(mSv)	
	*Brain	+Lens of eye	Brain	Lens of eye
Adult	2.940 ± 1.120	2.947 ± 1.113	0.147 ± 0.056	0.884 ± 0.334
Children	3. 918 ± 0.003	5.600 ± 0.001	0. 196 ± 0.001	1.680 ± 0.001

*NS (P=0. 1466)
+S (P =0.0003)

DISSCUSSION

Radiation is useful when used with care and the investigation justified. Otherwise it could be harmful. The injury could be immediate or delayed depending on the dose level received by the individual. In this study dose data from 32 patients (mean age of 36.48years) were collected to assess the dose to the brain and lenses of the eye during computed tomography of the head. Results showed that the mean absorbed dose to the adult brain was 2.940 ± 1.120mSv and the mean effective dose to the adult brain was 0.147 ± 0.056mSv. For the lens of the eye the mean absorbed dose was 2.947±1.113mSv and the mean effective dose was 0.884 ± 0.334mSv. For both the brain and the lens of the eye, both the mean absorbed dose and the mean effective dose were higher in children than in adults. In children the mean absorbed doses were 3.918 ± 0,003mSv to the brain and 5.600 ± 0.001 to the lens of the eye while the effective doses were 0.196 ± 0.001mSv to the brain and 1.680 ± 0.001mSv to the lens of the eye.

These dose levels appear quite low. The major concern however was the higher dose to children and the higher radiosensitivity of children and the possible excess lifetime cancer risk as noted by Chodick et al [18] and the fact that the threshold dose for cataract is uncertain as noted by Calssendorff et al. [10] No relationship was noted between dose and sex in this study. There was also no correlation between dose and the exposure parameters used.

CONCLUSION

This study used TLD chips to measure radiation doses to the brain and the lenses of the eyes and revealed that the radiation dose to the brain and the lenses of the eye were quite low. The effective dose of 0.884mSv to the lenses of the eyes (for adult) and 1.68mSv for children were below the threshold for cataract according to present knowledge. Also, the mean effective dose of 0.147mSv to the brain (for adults) and 0.196mSv for children seems insignificant. The fear is however the possible long term probability for induction of cancer by such low doses especial in children.

Since the dose has no relationship with the exposure parameters the only possible means of protecting patients include avoiding unnecessary scans (justification of practice) and optimization of dose by appropriate technique and use of eye protection (shield).

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