Cancer Risk to Paediatric Patients Undergoing CT Examination at the Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria.

ABSTRACT

Aims: The aim of this research work was to estimate the organ dose distribution and the associated radiation induced cancer risk for some commonly performed Computerized Tomography (CT) examinations at the Obafemi Awolowo University Teaching Hospital Complex, (OAUTHC), Ile-Ife, Nigeria.
Study design: The study was designed to estimate the radiological implications of the X-rays the paediatric patients were exposed to during routine CT examinations with the possibility of extending ther research to other teaching hospital, educating the radiological practitioners and the Nigeria public.
Place and Duration of Study: Department of Radiology, Obafemi Awolowo University Teaching Hospital Complex, (OAUTHC), Ile-Ife, Nigeria, between August 16, 2011 to August 15 2012.
Methodology: Well calibrated thermoluminescent dosimeters (LiF-100) were attached to the skin of paediatric patients such as skull, chest, abdomen, and pelvic in the path of the primary X-ray beam to determine radiation exposure during CT examination. The effective dose was calculated from the equivalent dose obtained from OAUTHC, and the cancer risk associated was computed using the lifetime attributable cancer mortality risks per unit dose as function of age at a single acute exposure as estimated.
Results: out of 258 paediatric patients scanned, the abdominal CT scan had the highest cancer risk ranging from digestive 357 per thousand patients to lung cancer risk of 4 per thousand patients. The risks estimated in this work were higher than the ICRP recommended value.
Conclusion: This research provides the preliminary data OAUTHC justifying the need to determine what goes on in other hospitals in Nigeria. There is need for the standardization of radiological CT examination and the procedures for Paediatric undergoing abdominal X-ray examinations in view of their sensitivity to radiation induced harzard.

Keywords: Paediatric, cancer, risk, CT and dose

1. INTRODUCTION (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

1. Introduction

Like in other teaching hospitals in Nigeria, Computerized Tomography (CT) is used for diagnostic purposes at the Obafemi Awolowo University, Teaching Hospital Complex, (OAUTHC), Ile-Ife, Nigeria. According to Linet et. al. and Mettleret. al. CT delivers much higher radiation doses than the conventional diagnostic X-rays [1, 2]. Berrington et. al. reported that when paediatrics are exposed to radiation during medical exposure the likelihood of expressing a delay in radiogenic cancers is high, because paediatrics have high radiosensitivity of the actively growing tissue and high probability of longer life expectancy [3]. The exposure of paediatrics to ionizing radiation is one of the few established risk factors for childhood cancers. The DNA changes occur when human body is exposed to ionizing radiation, and may act as an initiator in carcinogenesis. When larger doses are applied more cells will be affected, the affected cells can be killed, repair. The inadequate DNA-repair may result in mutations, which may change the reproduction and behaviour of

cell growth. Damages to this molecule leading to cancer can be caused through the direct ionization by radiation or by its indirect action in the formation of free radicals in water in close proximity to the genome. The National Academy of Sciences' National Research Council comprehensively reviewed biological and epidemiological data related to health risks from exposure to ionizing radiation, published as the Biological Effects of Ionizing Radiation [4]. Many efforts to record patient dose have been initiated by many international groups such as FDA (Food and Drug Administration) [5], ACR (American College of Radiology [6], and IAEA (International Atomic Energy Agency [7]. Since radiation exposure from CT examinations are all associated with higher doses but none has been initiated in Nigeria, this work will stand as initiator. In the work of Twombly et. al. the possibility that CT may cause more cancers than it prevents has been raised with respect to full-body screening CT examinations conducted in asymptomatic persons [8]. In Nigeria, the research conducted by Ogbole et. al. shows that neither physicians nor patients are generally aware of the radiation associated with CT, its risk of carcinogenesis, or the importance of limiting exposure among younger patients [9]. If we know how much radiation dose medical imaging delivers then the potential for harm it may cause can be compared against the potential for benefit. It has been established that making both physicians and patients aware of this risk is important [10-12]. There is a potential increase in the lifetime risk of radiation- induced fatal cancer from paediatric CT [13]. Some research work have been done on CT in Nigeria [14-16], no work has been done to estimate the actual patient-specific radiation dose received by paediatric patients in clinical practice and the life time attributable risk of cancer this work will also be a starting point in Nigeria and this work addressed it.

2. **MATERIALS AND METHODS**

A set of three hundred and fifty (350) well calibrated Lithium fluoride (LiF) TLD-100 was used for the collection of data from 258 paediatric patients at OAUTHC [15].

Computation of Effective Dose and Cancer Risk Estimates

An important aspect of this research work is to compute the effective dose from the equivalent dose obtained from OAUTHC Aborisade et. al. reported it [15], subsequently this work computed cancer risk associated with the procedures using the lifetime attributable cancer mortality risks per unit dose as function of age at a single acute exposure as estimated [13]. The resulting biological effects of different types of radiation having the same energy dose varies, additional biological weighting of the energy dose was necessary. This was done using the so-called equivalent dose. In ICRP paper [17] an equivalent dose for a certain organ or tissue is defined as

$$H_T = \sum_R W_R \, . \, D_{T,R} \qquad (1)$$

Where $D_{T,R}$ represents the dose applied to the organ T with respect to the type of radiation. W_R represents the radiation weighting factor, which for X-ray is [17]. The varying radiosensitivity of different organs and tissues were taken into account, by introducing a tissue weighting factor, W_T, which gives effective dose *E*. The effective dose *E* which is the sum of the weighted equivalent doses in all the tissues and organs and it is given by

$$E = W_T . H_T \qquad (2)$$

The induction of stochastic effects of carcinogenesis and genetic effect are major radiation risk to patients from CT examinations [17]. The effective dose is generally regarded as the best available dose descriptor for quantifying these stochastic risks in diagnostic radiology [18]. For paediatric the effective dose cannot be used to estimate the risk because for a given amount of energy that is put in, the corresponding doses will be substantially higher than that of adult , this leads to substantially higher effective dose [19]. The main technique used in this work was to multiply age-dependent lifetime cancer mortality risk (per unit dose) by estimated age-dependent doses produced by various CT examinations. The age dependence of the cancer mortality risk varies considerably from site to site as shown in Figure 1. Thus, for a highly inhomogeneous dose distribution produced by a CT examination, the age dependence of the overall cancer risk cannot be directly inferred from estimates of the total cancer mortality per unit effective dose. Rather, the age dependence of the risk for the various groups sites are each separately calculated by applying appropriate site specific doses to the age and site-dependent risk, this site specific risks are then summed to yield the overall age-dependent lifetime cancer mortality risk.

The values of the dose measured from OAUTHC by various organs were used to estimate the cancer risk. The specific groupings of potential types of cancer for which evaluated radiation-induced risks are available are leukemia, breast (for female) cancer, lung cancer digestive system cancer and other cancer using the estimate lifetime attributable cancer mortality risks per unit dose as function of age at a single acute exposure as estimated by the National Academic of Science BEIR V [21]. In this work other cancer means cancer of brain, thyroid, bladder, kidney, adrenal gland, spleen, thymus, skin, bone testes (for men) and uterus (for female) and ovaries (for women), while digestive cancer means cancer of colon, stomach, liver, pancreas, esophagus, and small intestine. For leukemia, lung, and breast cancer in female dose to the bone marrow, lung and female breast were respectively used. For digestive cancer, a weighted average of the

doses to the relevant organs was used, the weighting consisting of the relevant radiation-carcinogenic sensitivities of these organs. Thus, the dose to the digestive organs was computed as

$$D_{digestive} = \frac{\sum_T w_T . D_T}{\sum_T w_T} \qquad (3)$$

Where the summation is over the tissues (T) of the colon, stomach, liver, pancreas, esophagus, and small intestine, w_T are the weighting factors representing the evaluated relative radiation-carcinogenic sensitivities of the different tissues and were taken from 1990 International Commission of Radiological Protection recommendations [13]. Similarly, dose other cancer was computed as

$$D_{other} = \frac{\sum_T w_T . D_T}{\sum_T w_T} \qquad (4)$$

Where the summation is over the tissues (T) of the brain, thyroid, bladder, kidney adrenal gland spleen, thymus, skin bone testes (for male) and uterus and ovary (for female).

Graph A **Graph B**

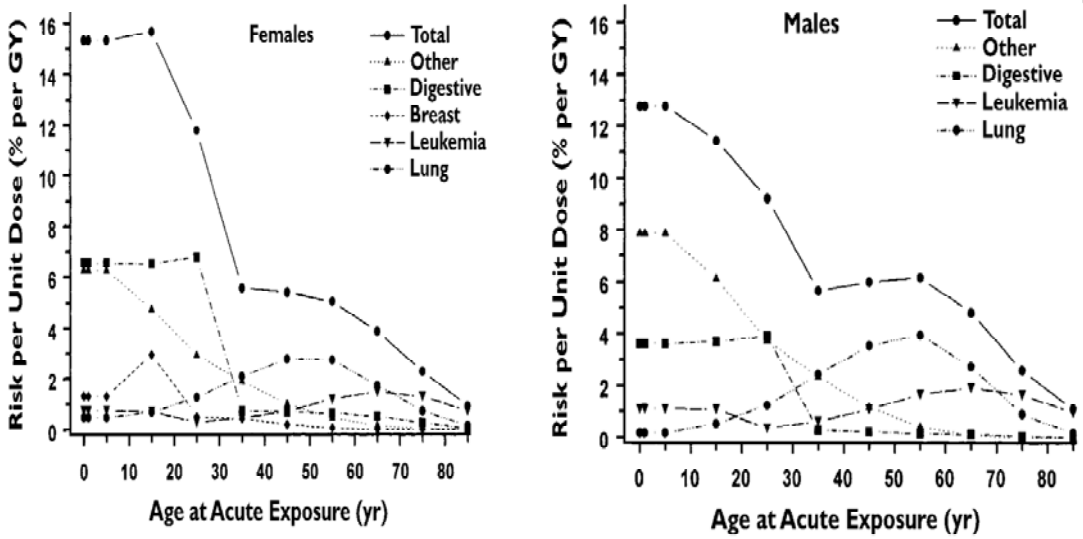

Figure 1: Breakdown by Cancer Type. A and B, Graphs show breakdown by cancer type of risk per unit dose for females (A) and males (B) of lifetime attributable cancer mortality risks as a function of age at a single acute exposure as estimated by the National Academy of Sciences BEIR V (Biological Effects of Ionizing Radiations) committee. [21].

3. RESULTS AND DISCUSSION

A total of two hundred and fifty eight (258) paediatric patients were scanned at OAUTCH for a period of one years. The rate at which paediartics were scanned at the hospital was low because of the high dose involved in CT examination; therefore most of them were examined with Magnetic Resonance Imaging (MRI).

Out of the 258 who had CT examinations 143 (55.43%) are male while 115 (44.57%) are female. Out of the 258 paediatrics 127 of them had CT examination of the skull, 61 abdomen while 70 had chest CT. Contrast media was used on 182 of the patients while no contrast was used on 76 of the patients because of the nature of the examination involved. Samples of the effective doses calculated using equation (2) from the equivalent dose at OAUTHC is presented in table 1-3.

Table 1: The Effective Dose for Various Organ/Tissue for Patients who Undergone Chest CT Scan at OAUTHC.

	Bone marrow	Brest	Colon	Liver	Lung	Ovary	Prostate	Stomach	Thyroid	Uterus	Bladder	Reminder
17 hours male	1.032	NA	1.032	0.344	1.032	NA	0.0785	1.032	0.043	NA	0.026	3.98

45 days male	0.141	NA	1.583	0.528	1.583	NA	0.066	1.583	0.046	NA	0.022	7.64
11 years male	3.833	NA	0.028	0.09	0.028	NA	0.028	0.028	1.278	NA	0.0092	26.7

Table 2: The Effective Dose for Various Organ/Tissue for Patients who Undergone Chest CT Scan.

Age (years)	Bone marrow	Brest	Colon	Liver	Lung	Ovary	Prostate	Stomach	Thyroid	Uterus	Bladder	Reminder
17 hours male	1.032	NA	1.032	0.344	1.032	NA	0.0785	1.032	0.043	NA	0.026	3.98
45 days male	0.141	NA	1.583	0.528	1.583	NA	0.066	1.583	0.046	NA	0.022	7.64
11 years male	3.833	NA	0.028	0.09	0.028	NA	0.028	0.028	1.278	NA	0.0092	26.7

Table 3: The Effective Dose for Various Organ/Tissue for Patients who Undergone Skull CT Scan at OAUTHC.

	Bone marrow	Brest	Colon	Liver	Lung	Ovary	Prostate	Stomach	Thyroid	Uterus	Bladder	Reminder
4 months male	2.607	NA	0.095	0.012	0.095	NA	0.085	0.035	0.869	NA	0.012	17.966
15 years female	8.393	0.1084	0.1084	0.036	0.1084	0.0094	NA	0.1084	2.798	0.014	0.0047	58.25
2 years male	3.529	NA	0.114	0.0084	0.114	NA	0.0251	0.0251	1.1765	NA	0.0084	24.42
9 years female	7.577	0.106	0.106	0.035	0.106	0.07	NA	0.106	2.526	0.011	0.0036	52.56

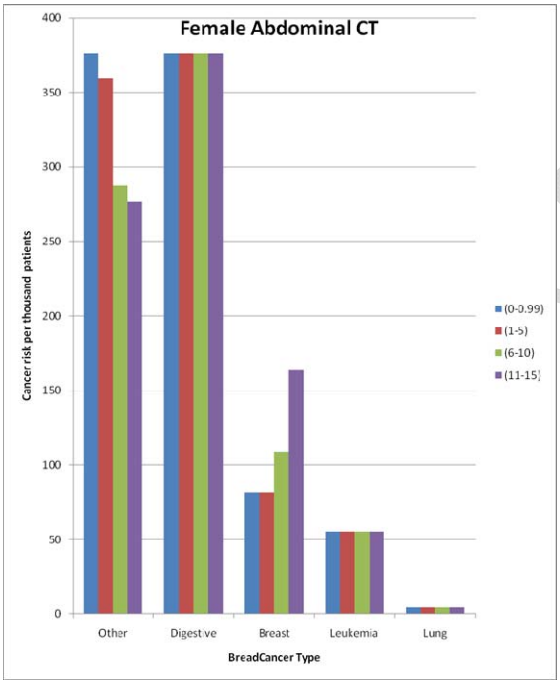

Figure 2: The Estimated Cancer Risk per Thousand Patients from Patients who had Abdominal CT Scan.

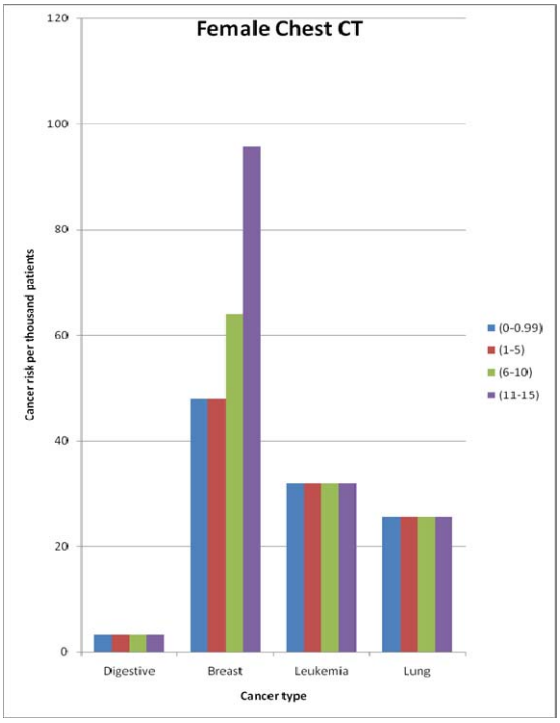

Figure 3: The Estimated Cancer Risk per Thousand Patients from Paediatric Patients who had Chest CT Scans.

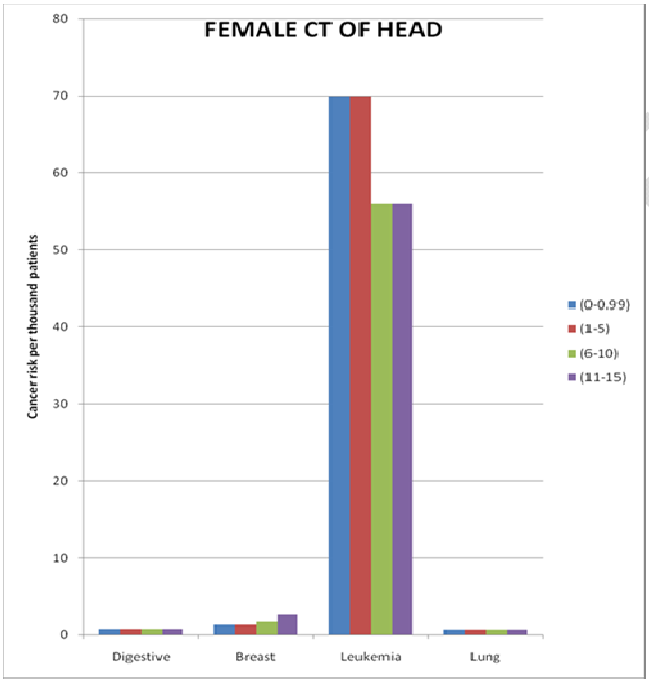

Figure 4: The Estimated Cancer Risk from Paediatric Patients who had Skull CT Scans.

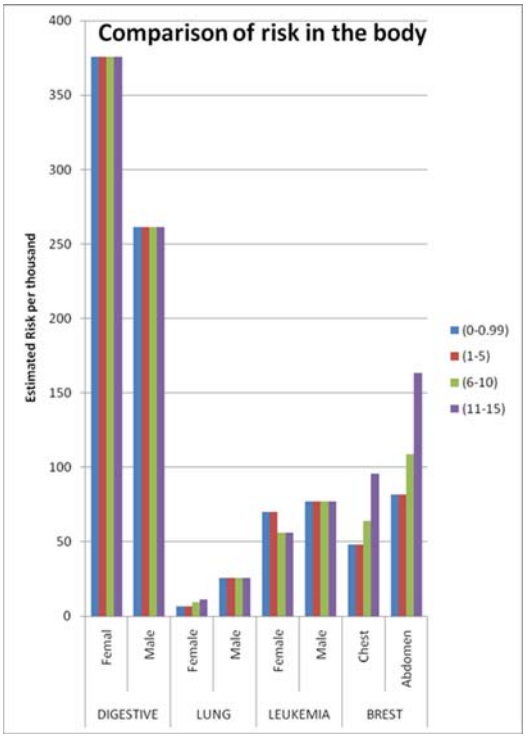

Figure 5: The Comparison between Male and Female Estimated Cancer Risk from Paediatric Patients who had CT Scans at OAUTHC.

Estimated Risk of Cancer from CT Examination

Equation 2 was used to calculate the effective dose for the following organs active bone marrow, breast, colon, liver, lung, ovary, prostate, stomach, thyroid, uterus and urinary bladder. The result is presented in Tables 1-3.

The value of the lifetime cancer mortality risks attributable to radiation from a paediatric CT examination in this work is estimated to be very high. For example, a best estimate of the lifetime cancer mortality risk attributable to the radiation exposure from a single abdominal CT examination in 375 in 1,000 while 70 in 1,000 for head CT examination, instead of 1 in 550 and 1 in 1,500 respectively obtained by Brenner et al.[13] as shown in Figures 2 and 4. If we multiply this by the number of CT examination performed on paediatric yearly in OAUTHC, we can see that the number is significant.

Form CT examinations considered in this work—abdominal and head—the dominant predicted induced malignancies are, respectively, of the digestive organs and of leukaemia (the brain) Figure 5. Female are more radiosensitive than male as shown in Figure 5. Several studies have suggested that a technique with significant reduction in exposure (milliampere-seconds) could be adopted for paediatric CT examinations without significant loss of information Robinson et al. (1986) [22-25] reduction in the dose will lead to corresponding reduction in risk.

Comparison of Risk in the Body

Figures 2 to 4 show the estimated lifetime cancer mortality risk attributable to a single CT examination performed on paediatric at different ages. Results are shown for three of the most common routine CT examinations, CT of chest, CT of the head and CT of the abdomen.

Breakdowns of the estimated lifetime cancer mortality by sex and by site are shown in Figure 5. For head CT examinations, the estimated “other cancer” mortality category is dominated by brain cancer. For abdominal CT examinations, the risks are dominated by digestive organ cancer, primarily stomach, liver, and colon cancer. Overall, the estimated risks for abdominal CT examinations are significantly greater than those for chest and head examinations, primarily because of the larger combined lifetime mortality risks (per unit dose) for exposure of the digestive organs relative to exposure of the brain and thyroid.

Estimated lifetime cancer mortality risks from abdominal CT examinations are somewhat greater for women than for men, an effect that is caused by the significantly greater estimated risks per unit dose for digestive organ cancer in women (Figure 1). The sex effect for head examinations is smaller because estimated brain tumour risks do not vary greatly with sex.

Estimated lifetime cancer mortality risks breast cancer type is uniform from a newborn baby to 5 year old but increases with age from 6 year old to 15 year because the female starts developing breast from these ages.

4. CONCLUSION

The risks estimated in this work are higher than the ICRP recommended value and values obtained by Brenner [13]. The dose and the risks obtained in this work are age and sex dependent. The result of this work has shown that there is an urgent need for standardization of procedures in CT paediatric radiology in this teaching hospital.

CONSENT (WHERE EVER APPLICABLE)

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal."

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

The authors go the Ethics and Research Committee approval from the hospital with Registration number IBR/IEC/0004553

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