April 2009
ISSN 1596-9770

Entrance Skin Dose (ESD) Evaluation for Pediatric Chest Examinations in Minna And Ibadan

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Abstract
Children are more susceptible to harmful effect of radiation because of the greater cell proliferation rate. Special attention must thus be paid to reduce pediatric dose to the minimum dose possible. Pediatric dose from chest examinations for 184 patients in one facility each at Ibadan and Minna is presented. Thermoluminescent dosimeters (TLD) -100 chips were used to measure the air kerma of each pediatric patient and the entrance dose computed by multiplying the kerma with a backscatter factor of 1.30. The mean dose obtained in this work were found to be generally higher for each age category when compare with published values of United Nation Scientific Committee on Effects of Atomic Radiation (UNSCEAR) for the same age category. A comparison of this work with another on three other different hospitals shows that values in this work were lower. There is need for optimization of pediatric radiological examinations in Nigeria.
Key words: entrance dose, pediatric radiography, optimization, air kerma

Introduction

Diagnostic imaging is the largest manmade source of radiation exposure to the general public. It was estimated that diagnostic imaging and nuclear medicine contributed 88% to the collective effective dose of U.S population from manmade radiation sources (NCRP, 1987). Similar estimate showed that it was 96% in the U.K (NRPB, 1993). A national survey of patient doses in the U.K. demonstrated that there existed wide variations in the radiation dose received by patients for similar x-ray examination (NRPB, 1986). The entrance surface dose per film for normally the same type of radiograph typically ranged between 20 and 100 for individual patients (NRPB, 1990). A similar survey by the Food and Drug Administration of the U.S revealed that the ratio of the maximum to the minimum dose ranged from 9 to 127 (Gray, 1999). These shows that good imaging procedure is needed to reduce this dose variation to as low as reasonably achievable consistent with clinical significance of the image. Dose audit is the basis for optimization of good imaging procedure as this will reveal facility where dose are not as low as reasonably achievable for remedial actions to be taken.

Infants and children constitute 10% of the total number of radiological examinations worldwide (UNSCEAR 2000). Radiation protection in pediatric radiology deserves special attention because; neonates and children are more susceptible to harmful effects of ionizing radiation than adults at the same dose level (Strather *et al.* 1998). This is so because of their greater cell proliferation rate and long life span expectancy, which also increases the probability of late (delayed) effects of radiation. Consequently, the International Council on Radiation Protection (ICRP) in 1990 estimated a higher coefficient for stochastic effects and hereditary effects for pediatric patients than that of the average adult population. There is thus the need to pay close attention to doses delivered to children with the view to reducing it to as low as reasonably achievable while still maintaining diagnostically good image.

Pediatric dose surveys started receiving attention even in the developed countries after 1980 (Schneider *et al.* 1995). In Nigeria pediatric dose surveys are still very scanty. The need for proper dose audit of pediatric radiography in Nigeria and other developing countries arose from the fact that: there are few radiologists with experience in pediatric radiology. Therefore general radiologists who have no special knowledge of pediatric diseases and radiology carry out most of the children x-ray interpretations (Ogundare *et al*. 2004). This could lead though to diagnostically acceptable image but doses to children may not be as low as reasonably achievable.

The aim of this work is to estimate the entrance skin dose (ESD) for chest PA examination in two x-ray diagnostic centers in Nigeria. The centers are Niger state general hospital (NGH) and Two-Tees diagnostic centre (TTX). Further more the estimated ESD is to be compared with those obtained in other works and that published by the United Nation Scientific Committee on Effects of Atomic Radiation (UNSCEAR) in 2000.

Generally, dose measurements are carried out to: establish dose constraints; optimize methods; determine risk to patients (individuals); determine population effective dose and risk. Though this survey may not serve all the above purposes because of the number of patients and centers included but it will help to establish the need to further optimize method used in the centers included in this survey. This will be possible especially if pediatric chest doses are found to be high compare to UNSCEAR recommended level.

Materials and Methods

This study was carried out on two x-ray units used for both adult and pediatric patients in Nigeria. One of the units is at Niger state hospital (NGH) in Minna, northern Nigeria and owned by the state government. The other is at Two-Tees diagnostic centre, Ibadan in southern Nigeria (privately owned). The inclusion of these two x-ray units to a great extent was dictated by the number of patients they receive daily. Majority of people in Minna, due to economic challenges prefer to make use of government health care facility. Also there are very few private x-ray diagnostic centers in Minna, these account for the high patient influx daily at NGH. The erratic power supply in Ibadan and consequently the long queue witnessed at government x-ray diagnostic facility is the major reason why many people patronize private medical facility in Ibadan. Amongst the private practitioners in Ibadan TTX records the highest patient attendance. The implication of the high patient influxes in these two facilities is that dose values obtained from this work, to a good approximation will indicate the general radiation dose to pediatric patients in these areas due to x-ray diagnostic procedures.

For each facility, available machine and personnel data are made available and observed where possible were recorded as shown in table 1. The ESD reported in this work are those of 134 pediatric patients from the two centers mentioned. During the period of measurements, there were children undergoing x-ray diagnostic for other projections different from chest examinations but chest x-ray has statistically significant number of patients. The distribution of patients by age in this survey is shown in table 2.

Table 1. Personnel and specific data of x-ray machines used in the hospitals.

	NGH	**TTX**
Manufacturer	G.E.C. Medical Matchlet x-ray U.K	G.E.C. Medical Matchlet x-ray U.K
Model/Type	Dynamax 40	Roentgen 201
Year of manufacture	-	-
Year of installation	-	1993
Inherent filtration	1.0 mmAl	1.5 mmAl
Added filtration	1.5mmAl	-
Film Type	Agfa	Kodak
Processor	Manual	Manual
No. of radiographer	2	2
No. of radiologist	2	2
Use of Grid	yes	No
Target angle	12°	16°

Table 2. patient distribution by age.

Age group	**Numbers of Patients**		
	NGH	**TTX**	**All**
1m – 1yr	25	3	28
1yr – 5yr	14	9	23
5yr - 10yr	22	27	49
10yr -15yr	13	21	34

Some radiological parameters recorded for each pediatric chest examination in each center include, tube voltage (kVp), product of tube current and time of exposure (mAs) and Focus to Film Distance (FSD). The mean values of these parameters are shown in table 3.

Well annealed LiF TLD-100 chips with closely matched sensitivities (within ±5%) were employed for the measurement of air kerma for each patient. The TLD could not be used on the patients directly because of the difficulty involved in attaching it to children's body without upsetting them. Further more parents were apprehensive about attaching the TLD on their children's body due to ignorance. Sensitivity and linearity calibration of the TLD were performed at diagnostic energies using irradiation facilities at the secondary standard dosimetry laboratory at the Federal Radiation Protection Service (FRPS), university of Ibadan, Ibadan Nigeria. For each measurement, the x-ray machines parameters were set to the ones used for each patient. The TLDs were then suspended in air at patient position using the FSD used for each patient and at the center of the x-ray beam before exposure. The exposed TLDs were then packed in black polythene bags and transported back to FRPS where they were read using a TLD reader (Harshaw 6600). The ESD for each patient was then estimated by multiplying the kerma obtained by a back scatter factor of 1.30 as recommended by the European Commission guidelines (EU, 1996).

Table 3. Mean radiological parameter used at the hospitals

x-ray center	Radiological parameter kVp	mAs	FSD(cm)
TTX			
1m – 1yr	86.33	22	114.67
1yr – 5yr	85.89	23	113.33
5yr - 10yr	85.11	24	112.56
10yr -15yr	85.81	24	109.33
NGH			
1m – 1yr	69.40	9.8	174.76
1yr – 5yr	72.86	32	174.43
5yr - 10yr	74.00	45	173.50
10yr -15yr	72.85	43	170.46

Results and Discussion

For the purpose of comparison of the ESD values in this work with those found in the UNSCEAR 2000 guidance value for pediatric patient ESD, patients' statistics were stratified into age groups that conformed to those used by UNSCEAR. The result shown in table 4 are those of pediatric patients examined during the period of this study. In each center a total of 50 days was used for collecting patient data and measurement of ESD. A total of 184 pediatric patients were included in this study from the two hospitals. The patients were randomly selected while excluding critically ill patients. The result of the measured ESD is as presented in table 4. at NGH, the mean ESD of the patients in the age group 1m -1yr is the least, while those of 5-10yr is the highest. The radiological parameters used for the patients in each age bracket could be used to explain the variation in measured ESD. The same focus to film distance (FFD) of 180cm was used for all age groups at NGH. The slight variation in FSD is obviously due to variance in patient thickness. The lower dose of patients in group 1m-1yr could be attributed to the lower mAs used and slightly higher FSD. The mAs is proportional to the exposure, while the inverse square law exists between dose and FSD. Although the lower voltage used should have increased the dose but it seems the lower mAs and slightly high FSD have cancelled out the effect.

At TTX, same FFD was also used for all the age brackets, similarly other radiological parameters were found to be almost the same. This might explain the almost same ESD across all age groups. The only radiological parameter that could explain the slight variation in ESD in this centre is patient thickness (FED).

A comparison between ESD obtained in this work and UNSCEAR (2000) recommended values shows that for all age group, mean ESD from this work are higher than that of UNSCEAR. for age group 1m-1yr it is more by a factor of almost 22, for 1yr-5yr, it is approximately a factor of 15 and it is by a factor of about 12 and 10 for the remaining two age groups (table 5).

Also comparing this work with that of Ogundare *et al.* (2004) obtained from hospitals in Nigeria differing from those used in this work reveals that the ESD in this work are lower for age groups (table 5).

Table 4. Mean ESD (standard deviation) of the pediatric patients in each hospital.

Age distribution	Entrance surface dose (mGy)		
	NGH	TTX	ALL
1m – 1yr	0.19 (0.01)	0.44 (0.07)	0.22 (0.09)
1yr – 5yr	0.29 (0.09)	0.46 (0.06)	0.41 (0.11)
5yr - 10yr	0.40 (0.22)	0.46 (0.06)	0.42 (0.16)
10yr -15yr	0.35 (0.23)	0.47 (0.06)	0.51 (0.09)

Table 5. Comparison of mean ESD in this work with a similar work in Nigeria and UNSCEAR values.

Age distribution	This work	UNSCEAR 2000	Ogundare *et al.* 2004
1m – 1yr	0.22	0.02	0.35
1yr – 5yr	0.41	0.03	0.52
5yr - 10yr	0.42	0.04	0.49
10yr -15yr	0.51	0.05	1.90

Conclussion and Recommendation

This study has highlighted the need to continue to audit doses received by pediatric patients who undergo radiological examinations. Although, risk-benefit analysis would predict that for patient with more clinical symptoms, higher dose levels are acceptable to provide diagnostic information which can significantly affect either survival or quality of life, optimization of technique still needs to be improved.

The fact that patient entrance dose obtained in this work is high compare to UNSCEAR published values, implies that more work still need to be done on optimization of radiological procedure in the centers visited, and perhaps in Nigeria at large. This is further emphasized by the result of Ogundare *et al*. (2004). The values of the standard deviation (ssd) indicate the variation in ESD for radiograph taken for patient in the same age category. If a lower dose could be delivered for same radiographic image, then higher dose would not be necessary if equipment and procedure are better optimized.

One of the ways to reduce dose difference for patient in the same age bracket and requiring similar or different image information is to select radiographic parameters that fits individual patient's requirement rather than use same parameter for all cases. The choice of parameter will have to be dictated by factors among which are: image quality and type of information required (nature of illness), patient's age and size.

There is an urgent need for a national survey in Nigeria so as to set a national guidance level for radiological practice. This will go a long way in reducing pediatric patient dose and the risk associated with children exposure to x-rays. There is also need for radiographer to go for refresher courses so as to have a better understanding of pediatric diseases and image requirement.

References

European Commission. (1996). European guidelines on quality criteria for diagnostic radiograic images, EUR 16260EN. Luxembourg: Office for official Publications of the European Communities.

International Commission or Radiological Protection (ICRP), 1990 recommendations of the ICRP. ICRP 60. oxford: Pergamon press. 1991.

Gray, J. 1999. Reference values – what are they? *American Association of Physicist in Medicine,Newsletter 24, 9-10.*

National Council on Radiation Protection and Measurement, NCRP. 1987. Report No. 93. ionizing radiation exposure of the population of the United State. NCRP, Bethesda, Maryland.

National Radiological Protection Board (NRPB). 1986. report No. R200, a national survey of doses to patient undergoing a selection of routine x-ray examinations in English ospitals. NRPB, Chilton, Didcot, U.K.

National Radiological Protection Board (NRPB). 1990. Document of the NRPB, vol.1, No.3, patient dose reduction in diagnostic radiography. NRPB, Chilton, Didcot, U.K.

National Radiological Protection Board (NRPB). 1993. Report No. R263, radiation exposure of the U.K population- 1993 Review. Chilton, Didcot, U.K.

Ogundare F.O., Ajibola C.L., and Balogun F.A. 2004. surveys of radiological techniques and doses of children undergoing some common x-ray examinations in three hospitals in Nigeria. *Medical Physics 31*(3). 521-524.

Permulter N, Arthur R.J, Bellufi G, Crook V,Horwitz E, Kramer P, Montagne J.P, Thomas P.S, and Schneider K. (1998). The quality criteria for radiographic images in pediatrics. *Radiation Protection Dosimetry 80*, 45-48.

Schneider K. (1995). Evolution of quality assurance in pediatric radiology. *Radiation Protection Dosimetry. 57*, 119-123.

Stather J.W, Muirhead C.R, Edwards A.A, Harrison J.D, Lloyd D.C, and Wood N.R. (1998). Health effects models developed from the 1988 UNSCEAR report. NRPB report R226.

United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation.2000. *Report to the General Assembly*, with scientific annexes.