ASSESSMENT OF BODY ORGAN DOSES IN CONVENTIONAL RADIOLOGY IN AKWA IBOM, NIGERIA

[*]ESEN, NSIKAN. U. AND [+]OBED, RACHEL. I.
[+]Department of Physics, University of Ibadan, Ibadan, Nigeria.
[*] Department of Physics, Akwa Ibom State University, Uyo, Nigeria.
***Corresponding author**:+234(0)8037623537,
e-mail: nsikanjesus@yahoo.com

ISSN: 2141 – 3290
www.wojast.com

ABSTRACT: The advancement of practical methods for patient dose assessment in radiology is further more desirable since the Quality Assurance Programs, including patient dosimetry, are legal requirement nowadays in most countries as well as in Nigeria. The application of software package to perform ESD (Entrance surface Dose), ED (Effective Dose), BOD (Body Organ Dose) is a modern resource in dosimetry and is being widely used in hospitals. The software used in this work was the Caldose_X5. The Monte Carlo calculation makes use of the technical exposure parameters and patients information. The organ absorbed dose for 4 examinations in 720 adult patients, for AP, PA and RLAT projections have been assessed for the most common examinations: Thorax, Cranium, Abdomen and Pelvis. The highest BOD were in Lungs (for Thorax PA projection - 124µGy), in the Eyes (for Cranium AP projection - 1191 µGy), in Gall bladder (Abdomen AP – projection 877 µGy) and in Testes (Pelvis AP projection - 413 µGy). The results revealed that the examinations that imparted the highest doses to the patients were Cranium, Abdomen and Thorax.

INTRODUCTION

For over ten decades, X-rays have been used for diagnostic purposes. The use of X-rays for imaging purposes, however, exposes patients to ionizing radiation. The increasing use of X-ray in hospitals has made medical exposure an important source of radiation in the population collective dose, ISEA, (1996), and ICRP, (1996). Ionizing radiation has the ability to break apart biologically important molecules such as DNA in exposed cells and can cause harm. As a result, the amount of radiation received by patients undergoing X-ray examinations needs to be quantified to estimate the possibility of harm. Patient doses in radiography primarily depend on the entrance surface dose and the sensitivity of the organs and tissues irradiated during the radiographic examination, Faulkner, et. al. (1995). Ionizing radiations are widely used in medicine for diagnosis and for treatment. The number of people subject to low doses of radiation used in diagnostic radiology largely exceeds the number of patients submitted to higher doses used in radiotherapy treatments.

The advancement of practical methods for patient dose assessment in radiology is further more desirable since the Quality Assurance Programs, including patient dosimetry, are legal requirement nowadays in most countries as well as in Nigeria.

METHODOLOGY

In order to increase the speed and efficiency of the patient dosimetry process, a window based computer programme, CALdose_X5 (calculation of Dose for X-ray diagnosis), has been developed. CALDose_X 5 is a software that enables the calculation of the Incident Air Kerma (INAK) based on the Entrance Surface Air Kerma (ENAK) by multiplying the INAK with a backscatter factor, as well as organ and tissue absorbed doses for posture-specific female and a male adult phantom. Using Conversion Coefficient (CCs) normalized to the INAK, the ESAK or the Kerma Area Product (KAP) for examinations frequently performed in X-ray diagnosis. In addition, CALDose_X5 determines the risks of cancer incidence and cancer mortality for the examination selected by the user. The programme is fast and enables the processing of large volumes of data without the need for invasive measurements on patients. The CALDose_X5 was originated and his group in Pernambuco, Brazil to automate and significantly speed up the process. Kramer, *et.al.* (2010).

For the CALDOSE _X5 to work, it is necessary to furnish the output in mGy/mAs, of all X-rays machines used in the evaluation of doses. Once the tube potential, the tube current, the exposure time, the FDD and FSD are known ESD could be calculated by this expression:

$$\text{ESD= Output } X\left(\frac{kv}{80}\right)^2 X\left(\frac{100}{FSD}\right)^2 X\, mAs\, X\, BSF$$

The output is the mGy/mAs of the X-ray tube at 80kv at a distance 100cm normalized to 10mAs. BSF is backscatter factor for a particular examination at the required potential and was taken from NRPB numerical simulations, Hart, et. al. (2002).

Procedures

Fig.1 give name of the institution, room ID, patient's name and ID are optional. CALDose_X calculates adult risks for 35.0 years if no age is given by the user. Next, select sex and posture. Clicking on the examination drop down window shows the examinations available for the selected posture (Fig 1).

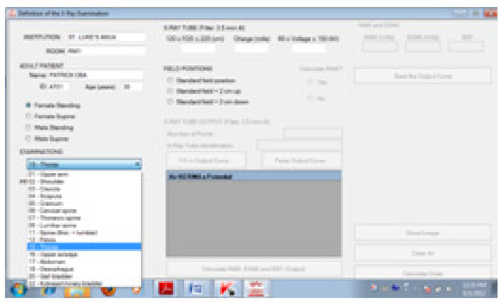

Fig.1: Definition of adult patient data, posture and view of possible X-ray examinations

Select the examination, the Focus-to-Detector Distance (FDD), the potential and the field position. The mAs needs to be defined only for absolute organ absorbed dose calculation. Apart from the standard filed position, two field positions +/- 2cm up and down can also be selected (Figs. 2 and 3).

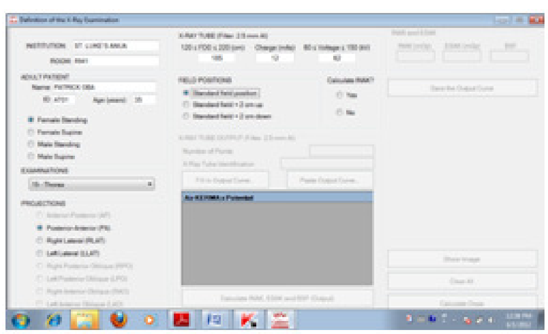

Fig.2: Selection of adult male, standing posture, examination of the abdomen AP, FDD =110 cm. 20 mAs and 75 kV for standard field position.

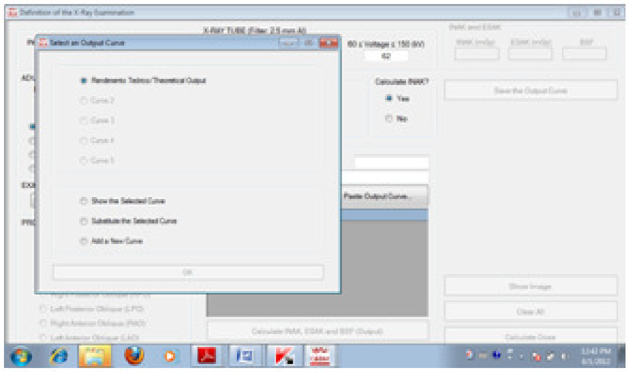

Fig.3: Selection of the theoretical output curve for calculating the INAK.

Select the theoretical output curve for 2.5 mm Al filtration offered by CALDose_X or type/paste the output curve of another X-ray tube into the table.

Based on the output curve, CALDose_X calculates the INAK and ESAK for the selected examination and exposure parameters, also using the Back-Scatter Factor (BSF) for the selected examination (Fig. 4).

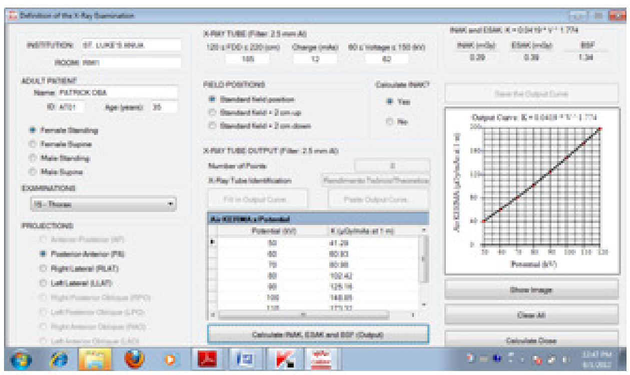

Fig.4: Theoretical output curve, the INAK, the ESAK and the back-scatter factor (BSF)

When clicking on “Show Image”, a visualization of the selected examination pops up (Fg. 5). Right-clicking on the image allows for the saving and/or printing of the image.

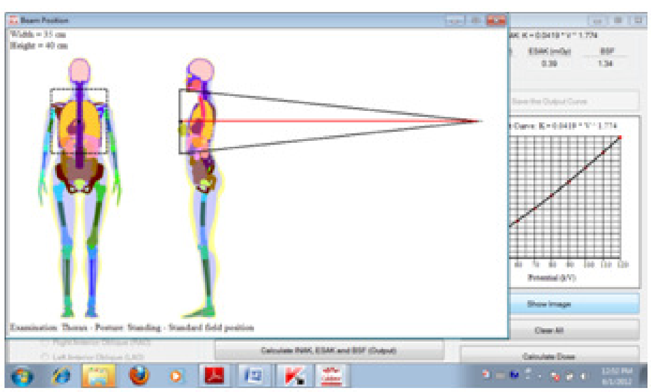

Fig.5**:** Visualization of the selected X-ray examination

Clicking on “Calculate Dose” as in Fig.6. It will show a small window for selecting the output mode of the results: organ and tissue absorbed doses or CCs. Fig. 6: shows the selection of calculating organ and tissue absorbed doses based on the INAK. In case of using the AKAP, the user has to fill in a value for the AKAP.

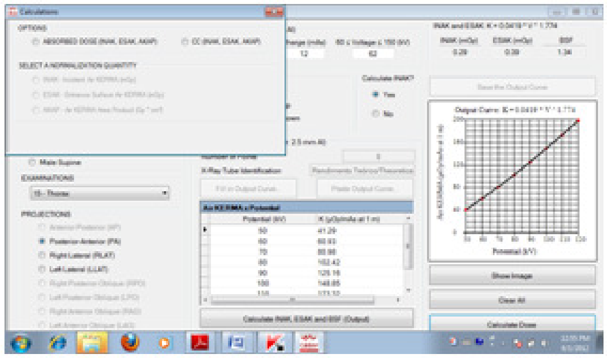

Fig. 6: Selection of output mode for results: Organ and tissue absorbed dose based on INAK

Fig.7 shows the results for the selected examination and exposure parameters. Organ and tissue absorbed doses are given in mGy and the statistical error in %. Absorbed doses with a statistical error greater than 10% are not indicated in the results. The “weighted MASH dose” represents the male contribution to the effective dose E. A similar quantity is given in the result for females.

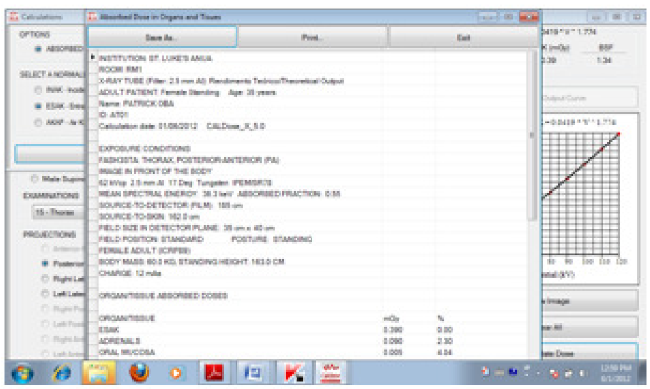

Fig.7: CALDose_X 5.0 organ and tissue absorbed doses, as well as cancer risks for the selected radiograph

In Fig.8, the selection for CCs was made, here normalized to ESAK and the results were displayed in table form. Different from previous versions, CALDose_X 5.0 also emits CCs for radiological risks at the end of the table. If no age was given by the user, CALDose_X 5.0 emits CCs for radiological risks for adults of 35 years of age (ICRP89 adult reference age).

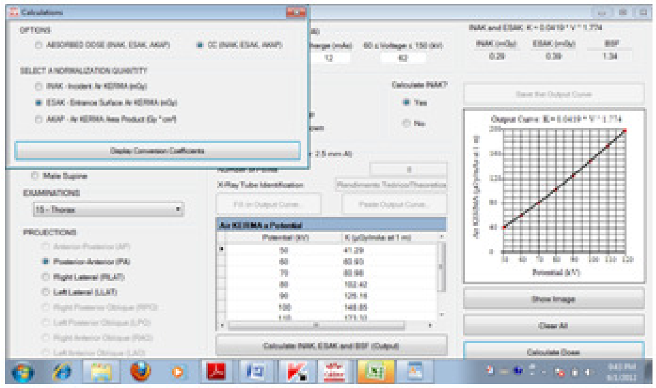

Fig.8: Selection of output mode for results: Conversion coefficients between organ and tissue absorbed doses and ESAK.

RESULTS AND DISCUSSION

Table 1: Body Organ Dose for examinations of Thorax for the three Hospitals considered (ANUA, REHAB & UUTH)

ORGAN/TISSUE	THORAX (ANUA)		THORAX (REHAB)		THORAX (UUTH)	
	PA	RLAT	PA	RLAT	PA	RLAT
Breast	0.00885	0.0343	0.0172	0.0415	0.01862	0.0525
Lungs	0.08555	0.0582	0.1241	0.0668	0.12402	0.0932
Skeleton	0.06375	0.0438	0.1122	0.0515	0.11887	0.0711
RBM[a]	0.07525	0.1078	0.1355	0.1303	0.14697	0.1734
BSC[b]	0.09721	0.1274	0.1745	0.1539	0.18912	0.2057

[a]Red bone marrow(RBM), [b]Bone surface cells (BSC)

Table 2: Body Organ Dose (BOD) for examinations of Cranium for the three Hospitals considered (ANUA, REHAB & UUTH)

ORGAN/TISSUE	CRANIUM(ANUA)		CRANIUM(REHAB)		CRANIUM(UUTH)	
	AP(mGy)	RLAT(mGy)	AP(mGy)	RLAT(mGy)	AP(mGy)	RLAT(mGy)
Brain	0.2047	0.1991	0.1145	0.2031	0.1168	0.2216
Eyes	0.3197	0.3488	1.1035	0.3237	1.1911	0.4156
Skeleton	0.2212	0.1942	0.1944	0.1976	0.1987	0.2179
RBM[a]	0.1699	0.1693	0.2020	0.1673	0.2012	0.1802
BSC[b]	0.2034	0.2027	0.2426	0.1962	0.2421	0.2143

Table 3: Body Organ Dose (BOD) for examinations of Abdomen for the three Hospitals considered (ANUA, REHAB & UUTH)

ORGAN/TISSUE	CRANIUM (ANUA, REHAB & UUTH)		
	AP	AP	AP
Colon wall	0.459487	0.49398	0.474125
Ovaries	0.188533	0.19221	0.181087
SMI	0.371436	0.38448	0.380175
Uterus	0.116897	0.11059	0.117789
Gall bladder	0.833385	0.88265	0.876625
Skeleton	0.112513	0.11528	0.110712
RBM[a]	0.074411	0.07608	0.072725
BSC[b]	0.093692	0.09582	0.091223

Table 4: Body Organ Dose (BOD) for examinations of Pelvis for the three Hospitals considered (ANUA, REHAB & UUTH)

ORGAN/TISSUEmGy	PELVIS (ANUA, REHAB & UUTH)		
	AP(mGy)	AP(mGy)	AP(mGy)
Colon wall	0.358385	0.407925	0.418912
Ovaries	0.285346	0.255481	0.346958
Testes	0.413154	0.466154	0.485223
Uterus	0.199038	0.225464	0.135563
Prostate	0.228923	0.126167	0.244343
Skeleton	0.123667	0.144323	0.149832
RBM[a]	0.116256	0.156675	0.142052
BSC[b]	0.315511	0.166723	0.175775

In total, 720 samples of patient were included throughout the three hospitals. All the three hospitals undertook the six commonly performed X-ray examination. All the hospitals had 40 patients in each of the examination considered. Both sexes were included in this study.

Tables 1 – 4 present the mean distribution of the Body Organ Dose (BOD) for the three hospitals considered. All the hospital considered used low tube potential and three of them employed filtration of 2.5mmAL. These filtration values (2.5mmAL) were not measured, but were given by the radiographers.

From the results (Tables 1 – 4), there is a wide difference in patient's doses within the hospitals though the mean dose does not really vary greatly from one hospital to another.

The organ absorbed dose or Body organ dose for a total of 4 examinations in 720 adult patients, for AP, PA and RLAT projections have been evaluated for the most common examinations: Thorax, Cranium, Abdomen and Pelvis. The highest BOD was in Lungs (for Thorax PA projection - 124µGy), in the Eyes (for Cranium AP projection - 1191 µGy), in Gall bladder (Abdomen AP – projection 877 µGy) and in Testes (Pelvis AP projection - 413 µGy). It could be observed that the examinations that imparted the highest doses to the patients were Cranium, Abdomen and Thorax.

CONCLUSION

In view of the global concern about the Quality Assurance Programs in diagnostic x-ray, including patient dosimetry, an assessment of body organ doses in conventional radiology in Akwa Ibom, Nigeria has been studied. The body organ dose values were observed to be consistent with the range of value on the existing knowledge. Values of the present study were compared with reference standard levels and the values obtained on the present study are mostly comparable.

This implies that the radiation risk to an average patient in the hospitals in this work is low and the risk to workers in the hospitals will be generally low. The findings show that there is need for quality assurance programs and monitoring aimed at reducing patient's dose. This can be achieved by organizing regular workshops and conference for radiographers, setting of guidelines for different exposure, and establishing of diagnostic reference levels with which individual hospitals may compare their dose.

REFERENCES

International Atomic Energy Agency (1996): International basic safety standards for protection against ionizing radiation and for the safety of radiation sources, IAEA Safety Series No. 115. Vienna, Austria.

International Commission on Radiological Protection (1996). Radiological protection and safety in medicine. Annals of the ICRP 26, Oxford: England, Pergamon press.

Faulkner K, Jones AP, Walker A Safety in diagnostic radiology (1995): National radiological protection board report No. , The institute of physical sciences in medicine, York: UK.

Kramer, R., Khoury, H. J. and WVieira, J.and Luiz F. (2010): CALDose X—a software tool for the assessment of organ and tissue absorbed doses, effective dose and cancer risks in diagnostic radiology. *Radiation Protection Dosimetry*. 1–6. doi:10.1093/rpd/ncq278.

Hart, D., Hillier, M. C. and Wall, B. F. (2002): Doses to patients from medical X-ray examinations in the UK. Chilton, Didcot, UK: NRPB.