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Radiology

Assessment of Organs Dose to Patients Undergoing Skull X-Ray Examinations

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Original Research Article

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Abstract: This study was done in two hospitals in Sudan in Khartoum state to assess organ dose to patient undergoing skull x-ray. The CAL-Dose software was used for calculations of entrance surface air kerma (ESAK) and organs doses by entering the patient information and parameters (age, ID, sex, name, and field of position, kV, mAs, and machine type). Variation was found in values of the entrance surface air kerma ESAK and organ dose at each hospital. These variations were due to different settings of the exposure factors to each patient. When comparing the values of ESAK to each hospital with the international diagnostic reference level (DRL) it was found that they were lower than DRLs, and it was found that the value of hospital 1was greater than that of hospital 2, and the eyes received higher organ radiation dose as compared with (oral mucosa, salivary gland, brain doses) because their radio-sensitivity is higher.
Keywords: skull x-ray, kerma (ESAK), hospital.

INTRODUCTION

Radiation is an energy transmitted through a medium as either electromagnetic (EM) waves or subatomic particles [1]. Radiation is classified into two main categories, nonionizing and ionizing, depending on its ability to ionize matter. Non-ionizing radiation cannot ionize matter because its energy is lower than the Ionization potential of matter. Ionizing radiation can ionize matter either directly or indirectly. Its energy exceeds the ionization potential of matter. It contains two major categories directly and iindirectly ionizing radiation.

Directly ionizing radiation deposits energy in the medium through direct Coulomb interactions between the directly ionizing charged particle and orbital electrons of atoms in the medium. Indirectly ionizing radiation (photons or neutrons) deposits energy in the medium through a two steps process: In the first step a charged particle is released in the medium (photons release electrons or positrons, neutrons release protons or heavier ions). In the second step, the released charged particles deposit energy to the medium through direct Coulomb interactions with orbital electrons of the atoms in the medium. Directly ionizing radiation consists of several groups of charged particles, such as light charged particles (electrons and positrons), heavy charged particles (Protons, deuterons, and alpha particles), and heavier charged particles (e.g., carbon-12) [2]. Many types of radiation are harmless, but ionizing radiation can injure humans. We are exposed to many sources of ionizing radiation. These sources can be divided into two main categories: natural environmental radiation and man-made radiation. [1]. X-ray has multiple properties that give it special diagnostic value, and with increased incidence of cancer it became necessarily to study the other side of x-ray specially its effect on human health and body systems. Diagnostic X-rays are used for identifying diseases and other problems during medical examinations. The objective of any diagnostic x-ray examination is to produce images of patients with essential details and sufficient image quality so as to guide practitioners for effective and efficient diagnosis and treatment of various disease conditions. Because of the risks associated with the exposure of the patients to x-rays during the diagnostic x-ray examinations [3]. The human head is anatomical unit that consists of the skull and the brain [4]. Skull x-rays are performed to examine the nose, sinuses, and facial bones. Doctors may order skull x-rays to aid in the diagnosis of variety of diseases or injuries like (sinusitis, fractures, and tumors) [4]. Organ dose is quantity defined in ICRP publication 60 in relations to the probability of stochastic effects (mainly cancer induction) as the absorbed dose averaged over an organ. the quotient of the total energy imparted to the organ and the total mass of the organ. The unit is joule per kilogram and is given the special name gray (Gy) [5]. Radio-sensitivity is the measure of the response of tissue to ionizing radiation. Tissues vary in their sensitivity to the damaging effects of irradiation [4]. Radio sensitivity is divided into high, intermediate, and low radio sensitivity. Radiation dosimetry (or simply "dosimetry") deals with the measurement of the absorbed dose or dose rate resulting from the interaction of ionizing radiation with matter [6]. The entrance skin dose (ESD) is the absorbed dose in the skin at a given location on the patient. It includes the backscattered radiation from the patient. It can be measured directly with a dosimeter on the patient or by multiplying the Incident Dose (ID) with a backscatter factor (B). The magnitude of the ESD also increases as the FSD is reduced [7].

MATERIALS AND METHODS

This study was carried out at two hospitals in Sudan, Khartoum state. A total numbers of 31 adult patients were examined. The geometrics and radiographic views were recorded for skull x-ray examination which was as follows (Antro-Posterior, Right – Lateral and Left- Lateral). The data were collected using sheet for all patients in order to maintain consistency of the information. The following parameters were recorded age, ID, name, and exposure factors. In hospital 1 the machine was shimazdu, maximum kVp was 120 and minimum 60 and maximum mAs were 25 and minimum 8, and 20 cases were imaged by this machine.

In hospital 2 the machine was shimazdu, maximum KVp was 120 and minimum 60 and the maximum mAs was 18 and minimum was 10 , and 12 cases were imaged by this machine.

CALDose_X

Is a software tool that enables the calculation of the Incident air kerma (INAK) based on the output curve of an X-ray tube and of the Entrance surface air kerma (ESAK) by multiplying the INAK with a backscatter factor, as well as organ and tissue absorbed doses for the adult posture specific female FASH and the male MASH phantoms, using conversion coefficients (CCs) normalized to the INAK, the ESAK or the Kerma area product (KAP) for examinations are frequently performed in X-ray diagnosis. Additionally, CALDose_X determines the risks of cancer incidence and cancer mortality for the examination selected by the user.

CALDose consists of three forms

3-1 First CALDose_X form: Definition of the X-ray examination.
3-2 Second CALDose_X form: Definition of the type of calculation.
3-3 Third CALDose_X form: Definition of the normalization quantity [8].

To calculate ESAK, machine output was obtained with two methods: in the first one the output in mR/mAs was measured directly at a distance of 100 cm from the x-ray tube using RAD-CHECK PLUS model 06-526 exposure meter (NuclearAssociates, Victoreen Division, NY, USA). In order to convert the output from mR/mAs to the output in mGy/mAs, dosimeter readings were multiplied by 0.0088to applies conversion. In the second method,the machine output was estimated indirectly using equation proposed by (Kothan and Tungjai), as indicated below [9].

Output (mR) =0.000522×kVp2×mAS: This equation could be used to estimate output and it altered the reliable and inexpensive techniques for patient dose measurement in routine diagnostic x-ray examinations. Cal dose-x software was used to calculate ESAK and organs doses. Data analysis was performed using the SPSS version 16 software.

RESULTS

Data were collected from departments of radiology in 2 hospitals in Khartoum state and used to calculate the ESAK and organ dose for 31 patients during skull x-ray. x-ray tubes outputs measurement results were represented in tables (1and 2).

Table-1: The output of the machine among different kilo voltage for hospital NO. 1

KVp	kVp2	mAs	Distance	Reading(mGy)
60	3600	8	100	340
70	4900	16	100	840
80	6400	18	100	1230
90	8100	36	100	3100
100	10000	40	100	4200
110	12100	44	100	5490
120	14400	25	100	3640

Table-2: The output of the machine among different kilo voltage for hospital NO. 2

KVp	kVp	mAs	Output(mR)	Output(mGy)
60	3600	10	18.792	0.16349
70	4900	10	25.578	0.22529
80	6400	10	33.408	0.29065
90	8100	10	42.282	0.367853
100	10000	10	52.2	0.45414
110	12100	10	63.162	0.54909
120	14400	10	75.188	0.653962

Table-3: Patients age and exposure parameters with average and range between brackets

Sex	Age	mAs	kVp	FDD
Male	28.6 (20-49)	10.21(6-22)	64.5(60-78)	100.6(100-115)
	63.6 (50-79)	10.33(6-22)	69.00(60-78)	110(100-115)
Female	29.39 (20-49)	10.46(6-22)	66.00(60-78)	100(100-115)
	55.00 (50-79)	10.33(6-22)	66.00(60-78)	100(100-115)

Table-4: Illustrates the statistical values of ESAK (maximum, minimum, mean) for each hospital

	RT-- LATERAL				LT -- LATERAL			
	Mean	max	Min	SD	mean	max	min	SD
HOSPITAL 1	0.70	1.79	0.48	0.341	0.93	1.33	0.60	0.30
HOSPITAL 2	0.48	0.84	0.28	0.21	0.42	0.44	0.41	0.12

Table-5: Shows the statistical values of ESAK in female for each hospital:

No	Projection	ESAk		
		mean	max	min
Hospital 1	RT- LATERAL	0.63	0.76	0.53
	LT - LATERAL	0.88	1.33	0.60
Hospital 2	RT- LATERAL	0.52	0.84	0.32
	LT- LATERAL	0.47	0.50	0.43

Table-6: Shows the statistical values of ESAK for male for each hospital

No	Projection	ESAK		
		mean	max	min
Hospital 1	RT-LATERAL	0.72	1.79	0.49
	LT - LATERAL	0.99	1.27	0.85
Hospital 2	RT- LATERAL	0.51	0.93	0.28
	LT- LATERAL	0.42	0.44	0.41

Table-7: Illustrates the ESAK compared with the dose reference levels

	Hospital 1	Hospital 2	UK	NRPB	IAEA
Skull RT-LATERAL	0.70	0.48	1.5	1.5	3
Skull LT- LATERAL	0.93	0.42	1.5	1.5	3

Table-8: Illustrates statistically the organ /tissue in female (RT-LA, LT-LA) for hospital 1

Organ/tissue	RT-LA				LT -LA			
	mean	Max	Min	SD	mean	max	Min	SD
ESAK	0.63	0.76	0.53	0.12	0.88	1.33	0.60	0.396
Brain	0.09	0.10	0.07	0.016	0.14	0.23	0.08	0.083
Eyes	0.15	0.19	0.13	0.029	0.22	0.34	0.15	0.106
Oral Mucsa	0.014	0.02	0.01	0.003	0.02	0.04	0.01	0.014
Salevery Gland	0.11	0.14	0.10	0.022	0.16	0.25	0.11	0.075

Table-9: illustrates statistically the organ /tissue in male (RT-LA, LT-LA) for hospital 1

Organ/tissue	RT-LA				LT -LA			
	Mean	Max	Min	SD	Mean	max	Min	SD
ESAK	0.72	1.79	0.48	0.411	0.99	1.27	0.85	0.242
Brain	0.08	0.22	0.06	0.052	0.15	0.20	0.13	0.041
Eyes	0.14	0.34	0.09	0.08	0.21	0.28	0.18	0.056
Oral Mucsa	0.01	0.04	0.01	0.008	0.03	0.03	0.02	0.007
Salevery Gland	0.13	0.32	0.08	0.073	0.18	0.24	0.16	0.047

Table-10: Illustrates statistically the organ /tissue in female (RT-LA, LT-LA) for hospital 2.

Organ/tissue	RT-LA				LT -LA			
	mean	max	min	SD	mean	max	Min	SD
ESAK	0.52	0.84	0.82	0.278	0.47	0.50	0.43	0.049
Brain	0.09	0.17	0.05	0.063	0.07	0.08	0.06	0.016
Eyes	0.14	0.23	0.08	0.081	0.12	0.016	0.13	0.10
Oral Mucosa	0.02	0.03	0.01	0.012	0.01	0.004	0.01	0.01
Salivery Gland	0.10	0.17	0.06	0.057	0.08	0.09	0.08	0.011

Table-11: Illustrates statistically the organ /tissue in male (RT-- LATERAL, LT-- LATERAL) for hospital 2

Organ/tissue	RT-LA				LT -LA			
	mean	max	min	SD	mean	max	Min	SD
ESAK	0.51	0.93	0.28	0.289	0.42	0.44	0.41	0.017
Brain	0.11	0.17	0.04	0.069	0.07	0.07	0.07	0.00
Eyes	0.12	0.22	0.08	0.065	0.09	0.09	0.09	0.01
Oral Mucosa	0.01	0.03	0.01	0.011	0.01	0.01	0.01	0.002
Salivery Gland	0.10	0.18	0.06	0.057	0.08	0.09	0.08	0.002

DISCUSSION

This study was done in two hospitals in (Sudan, Khartoum state); the main purpose was to assess the dose to the critical organs resulting from skull radiography. The radiographic images for 31 patients were collected. Before doses calculation of machines output were measured using Rad-check exposure meter as represented (table: 1 and 2) and then plotted against (kVp)2 as indicated in figures 4.1, 4.2 this relation must yield straight line relationship which represents most important machine QC test. In order to perform patient's dose calculation, machines parameters (kV, mAs and SDD) were selected during each examination. These parameters show large variation kV ranges from 60 to 78kv mAs from 6 to22mAs and SDD from 100 to115cm. These variations were attributed to several factors like (patient sizes machine performance, and technician experience). According to these varieties ESAK range from 41mGy to1.79mGy as shown in table 4(4.6). ESAKs were compared with dose reference level recommended by IAEA and NRPB (1999-2000) and UK as in table 4.7. The results of comparison showed that ESAK were within the accepted levels. Table (4.8,--, 4.11) shows comparison of dose received by the eyes, oral mucosa, salivary gland, brain, for each hospital. In hospital 1 the mean was higher than hospital 2 due to the absence of standard protocol among radiographic staff, and eyes dose was higher than oral mucosa, salivary gland and brain due to the high radiosensativety of the eyes.

CONCLUSION

Patient dosimetry is often applied as an instrument for optimization of radiological techniques and improvement of radiation protection to the patients. Inter hospital, interregional and international comparisons provide insight in the radiation exposure of patients. In this work we concluded that the mean ESAK in all examinations were below the DRLS, equipment's performance was contributing positively to these results. Also we found the value of ESAK in hospital 1 more than values in hospital 2. Dose received by the eyes was higher as compared to different other organs.

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