Estimation of Radiation Dose Received in Skull X-Rays in Emergency Radiology Department

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Abstract: ***Diagnostic X-ray examinations play an important role in the health care of the population. These examinations may involve significant irradiation of the patient and probably represent the largest man-made source of radiation exposure for the population. This study was performed in Emergency department of Khartoum teaching hospital in June 2015. This study performed to assess the effective dose (ED) received in lumbosacral radiographic examination and to analyze effective dose distributions among radiological departments under study. The study was performed in Khartoum teaching hospital, covering x-ray units and a sample of 50 patients. The following parameters were recorded age, weight, height, body mass index (BMI) derived from weight (kg) and (height (m)) and exposure factors. The dose was measured for skull x-rays examination. For effective dose calculation, the entrance surface dose (ESD) values were estimated from the x-ray tube output parameters for skull PA and lateral examinations. The ED values were then calculated from the obtained ESD values using IAEA calculation methods. Effective doses were then calculated from energy imparted using ED conversion factors proposed by IAEA. The results of ED values calculated showed that patient exposure were within the normal range of exposure. The mean ED values calculated were 3.03 $\pm$ 0.08 and 2.23 $\pm$ 0.31 for skull PA and lateral examinations, respectively. Further studies are recommended with more number of patients and using more two modalities for comparison.***

Keywords: radiation dose, skull, x-rays**,** radiology department

1. Introduction

When the ionizing radiation penetrates the human body or an object, it deposits energy. The energy absorbed from the exposure to radiation is called a dose. Radiation dose quantities are described in three ways: absorbed, equivalent, and effective. The amount of energy deposited in a substance (e.g., human tissue), is called the absorbed dose. The absorbed dose is measured in a unit called the gray (Gy). A dose of one gray is equivalent to a unit of energy (joule) deposited in a kilogram of a substance. When radiation is absorbed in living matter, a biological effect may be observed. However, equal absorbed doses will not necessarily produce equal biological effects. The effect depends on the type of radiation (e.g., alpha: beta: gamma etc) and the tissue or organ receiving the radiation. A radiation weighting factor (WR) is used to equate different types of radiation with different biological effectiveness. This weighted absorbed quantity is called the equivalent dose and is expressed in a measure called the (Sv). Sievert. Because doses to workers and the public are so law, most reporting and does measurements use the terms milisievert (mSv) and microsievert (μSv) which are 1/1000 and 1/1000000 of a sievert respectively. These smaller units of the sievert are more convenient to use in occupational and public settings. To obtain the equivalent dose, the absorbed dose is multiplied by a specified radiation weighting factor (WR). The equivalent dose provides a single unit which accounts for the degree of harm of different types of radiation. [1].

The importance of plain radiography of the skull has diminished in recent years due to the widespread availability of imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI). These play a much more significant role in the management of a patient with a suspected intracranial pathology and either one would usually be the modality of choice if such a pathology were suspected. Plain radiography does, however, still play a significant role in the management of patients with certain skeletal conditions and, to a limited extent, in trauma, e.g. when a depressed or penetrating injury is suspected or if the patient is difficult to assess. Consequently, a significant number of referrals are still received from accident and emergency department. In order to produce high –quality images of the cranium and minimize risk for the patient, the radiographer must have a good understanding of the relevant anatomy, positioning landmarks and equipments used for imaging. This should be coupled with an ability to assess the patient's ability and thus apply the correct technique in any given situation. [2].

One of the typical human diagnostic techniques is x-ray the x-ray examination depends on the range of radiation given to the subject. The radiation from the x-ray depends primarily upon the x-ray tube current (mA) tube voltage (kVp) and exposure time (s). Assessment of radiation exposure during X-ray examination are of great importance in range of radiation given to the subject. Pediatrics radiology should be governed with high professionals techniques to minimize radiation hazard on children while they are examined by X-ray parameters which involved in this project are X-ray tube voltage, X-ray tube current and the distance between the X-ray tube and patient's skin(child). Different radiographic examinations representing different radiographic techniques (tube voltage and current) were recorded reflecting the variety in the radiation exposure value computer program was used to calculate the entrance skin exposure the results show that the radiation exposure was still below the value of risk at this Time of exposure ranging between (0.04-0.14) second. Arthritis is recognized as a major public health problem. Arthritis and related musculoskeletal disorders are frequently chronic, disabling and painful. It is estimated that the total economic cost to the U.S. of musculoskeletal conditions was over $65 billion in 1984. Indirect costs from lost earnings and services represent a high proportion of these costs. These diseases represented the second most common cause of comorbidity in the Framingham Stu. The ideal mechanism for measuring the incidence and prevalence of these chronic conditions and their impact is through a survey which includes a physical examination, radiographs, laboratory tests and other procedures on a broad representative sample of the population. Case identification of the arthritidesis a major concern to those interested in obtaining complete and accurate figures. Many individuals do not know and therefore cannot report on what specific rheumatic disease affects them. The American Rheumatism Association definitions of a case are based on highly structured diagnostic criteria which, for osteoarthritis and rheumatoid arthritis, require radiologic evidence. With the emphasis in this survey on the health of the elderly, NHANES III provides a particularly appropriate context and population for the study of musculoskeletal conditions. The major diseases to be identified are rheumatoid arthritis, osteoarthritis and gout. Cases will be defined by use of questions on characteristic symptoms of the various disease; a physician's examination. Focusing on pain, tenderness, swelling and deformities of specified joints; x-rays of the hands and wrists, and knees; and various serological analyses, including rheumatoid factor and C-reactive protein. In addition to assessing the prevalence of the rheumatic disease, it is important to measure the burden of the diseases on the daily life of individuals. This information is necessary to establish health priorities and to monitor the effectiveness of interventions in rheumatic disease. A series of questions that cover mobility, physical activity and ability to care for oneself are included to determine the extent of functional impairment (Andriacchi et al, 2002).

2. Materials and Methods

A total of 50 patients were examined in two radiology departments in Khartoum teaching hospital. The data were collected using a sheet for all patients in order to maintain consistency of the information. The following parameters were recorded age, weight, height, body mass index (BMI) derived from weight (kg)/ (height (m)) and exposure parameters were recorded. The dose was measured for lumbosacral x-rays examination. The examinations were collected according to the availability.
This study involved patients undergoing skull radiographic examinations in the emergency department at Khartoum Teaching Hospital. The radiographic equipment used was Toshiba imaging system. It has a Polydoros LX 50 Lite high frequency generator with a general radiographic X-ray tube Opti 150/30/50HC. The target angle for the X-ray tube was 12°, and the measured ripple for tube potential was in the region of 1%. Total filtration for the X-ray system wasmeasure as 2.7 mm of aluminum equivalent. A single exposure control system was available for use in the under-table or vertical position. Preliminary work will establish that lateral lumbar spine examinations will carry out in two different ways depending on the clinical condition of the patient. Patients with good mobility were lying on their side on the X-ray table with the X-ray beam vertically above them. Immobile patients was lying supine on a trolley in front of a vertical bucky with the X-ray beam horizontal. Both techniques used exposure control and a tube potential range of between 85 kV and 100 kV depending on the patient size. Average tube potential for both techniques will be in the region of 93 kV. With dose audit, there were difficulties in complying with the requirement to collect dose data for patients of a particular weight range (50–90 kg) within the busy environment of an emergency department. In this case, the decision took to increase the sample size to approximately 50 patients and to exclude those of very large or small build but not require the collection of patient weight information. Separate sets of DAP dose data were collected for each of the two radiographic techniques.

ESD which is defined as the absorbed dose to air at the center of the beam including backscattered radiation, measured for all patients using mathematical equation in addition to output factor and patient exposure factors. The exposure to the skin of the patient during standard radiographic examination or fluoroscopy can be measured directly or estimated by a calculation to exposure factors used and the equipment specifications from formula below:

$$ESD = OP \times \left(\frac{KV}{80}\right)^2 \times mAs \times \left(\frac{100}{FSD}\right)^2 \times BSF \quad (1)$$

Where:
(OP) is the output in mGy/ (mA) of the X-ray tube at 80 kV at a focus distance of 1 m normalized to 10 mA s, (kV) the tube potential,(mA) the product of the tube current (mA) and the exposure time(s), (FSD) the focus-to-skin distance (in cm). (BSF) the backscatter factor, the normalization at 80 kV and 10 mAs was used as the potentials across the X-ray tube and the tube current are highly stabilized at this point. BSF is calculated automatically by the Dose Cal software after all input data are entered manually in the software. The tube output, the patient anthropometrical data and the radiographic parameters (kVp, mA s, FSD and filtration) are initially inserted in the software. The kinds of examination and projection are selected afterwards.

3. The results

For the group of patients where age distribution was measured, 12 % of patients were within the 0-9 years age range, 20 % of patients were within the 10-19 years age range, 32 % of patients were within the 20-29 years age range, 14 % of patients were within the 30-39 years age range, 2 % of patients were within the 40-49 years age range, 6 % of patients were within the 50-59 years age range, 6 % of patients were within the 60-69 years age range and 6 % of patients were within the 70-79 years age range. The key parameters for this group are shown in Table 1.

Table 1: Age distribution for both genders among the study sample

Age Group (years)	*Male*	*Female*
0-9	5	1
10-19	8	2
20-29	14	2
30-39	7	0
40-49	1	1
50-59	2	1
60-69	0	3
70-79	2	1

For the group of patients where Body Mass Index (BMI) was measured, 12 % of patients were within the 5 ± 10.6 BMI range, 20 % of patients were within the 22 + 0.05 BMI range, 32 % of patients were within the 20 ± 0.003 BMI range, 14 % of patients were within the 27 ± 0.03 BMI range, 2 % of patients were within the 26 ± 0.3 BMI range, 6 % of patients were within the 27 ± 0.01 BMI range, 6 % of patients were within the 37 ± 0.06 BMI range, 6 % of patients were within the 23 ± 0.03 BMI range and 6 % of patients were within the 23 ± 0.03 BMI range. The key parameters for this group are shown in Table 2.

Table 2: The mean and standard deviation of Body mass index distribution for both genders among the study sample

Age Group (years)	*Body Mass Index (BMI)*
0-9	5±10.6
10-19	22±0.05
20-29	20±0.003
30-39	27±0.03
40-49	26±0.3
50-59	27±0.01
60-69	37±0.06
70-79	23±0.03

For the group of patients where x-rays exposure factors (kVp and mAs) was measured, 12 % of patients were within the 51.5 ± 3.73 (kVp), 49.5 ± 10.1 (Second), 110± 22.36 (mA) range, 20 % of patients were within the 58.1 ± 5.52 (kVp), 51.7 ± 7.42 (Second), 142± 48.40 (mA) range, 32 % of patients were within the 61.6 ± 7.83 (kVp), 62.2 ± 26.2 (Second), 171.2± 38.1 (mA) range, 14 % of patients were within the 61.5 ± 7.48 (kVp), 65.1 ± 24.7 (Second), 140± 37.06 (mA) range, 2 % of patients were within the 70.0 ± 0.0 (kVp), 67 ± 0.0 (Second), 200± 0.0 (mA) range, 6 % of patients were within the 72.6 ± 14.6 (kVp), 52 ± 8.49 (Second), 186.6± 18.96 (mA) range, 6 % of patients were within the 67.3 ± 7.77 (kVp), 62.0 ± 6.03 (Second), 200± 0.0 (mA) range, 6 % of patients were within the 51.5 ± 3.73 (kVp), 49.5 ± 10.1 (Second), 110± 22.36 (mA) range and 6 % of patients were within the 67.0 ± 5.10 (kVp), 82.33 ± 27.33 (Second), 166.5± 1.49.36 (mA) range. The key parameters for this group are shown in Table 3-3.

Table 3: Shows the mean and standard deviation of exposure factors used for knee joint examination in the study sample

Age group	*mA mean± SD*	*kVp mean±SD*	*Second mean±sD*
0-9	110.0 ± 22.36	51.5 ± 3.73	49.5 ± 10.11
10-19	142.0 ± 48.40	58.1 ± 5.52	51.7 ± 7.42
20-29	171.25 ± 38.1	61.68 ± 7.83	62.18 ± 26.24
30-39	140.0 ± 37.03	61.57 ± 7.48	65.14 ± 24.78
40-49	200.0 ± 0.0	70.0 ± 0.0	67.0 ± 4.0
50-59	186.66 ± 18.96	72.66 ± 14.60	52.0 ± 8.49
60-69	200.0 ± 0.0	67.33 ± 7.77	62.0 ± 6.03

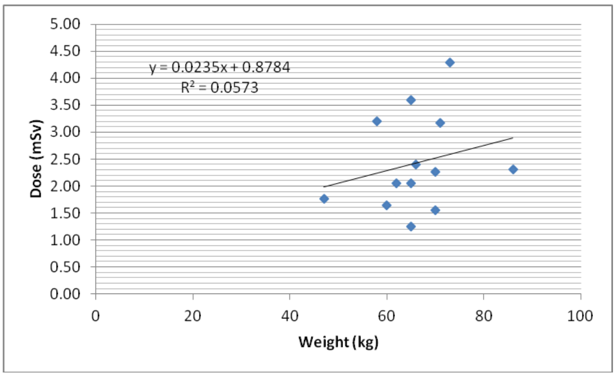

Figure 1. Correlation between Body weight (Kg) and dose

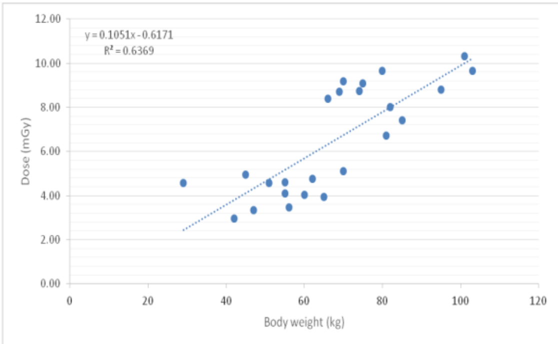

Figure 2. Correlation between Body Mass Index and dose

Table 4: Exposure factors, number of films and dose values for Lumbosacral exam

Projection	*Dose (mrem) (Mean ± SD)*	*ICRP Dose mrem (mSv)*
Postroanterior (PA)	3.03 ±0.08	3 (0.03)
Lateral	2.23 ± 0.31	1 (0.01)

4. Conclusion

This experimental study performed to measure of dose received in skull x-ray examination. In the emergency department, patients undergoing skull radiography examination are positioned either lying on their side on an X-ray table with the X-ray beam vertical or lying supine on a trolley with the X-ray examination have been evident from various international dose surveys. Reference dose levels provide a framework to reduce this variability and aid optimization of radiation protection. A total of 50 patients were examined in two radiology departments in Khartoum teaching hospital. The data were collected using a sheet for all patients in order to maintain consistency of the information. The following parameters were recorded age, weight, height, body mass index (BMI) derived from weight (kg)/ (height (m)) and exposure parameters were recorded. The dose was measured for lumbosacral x-rays examination. The examinations were collected according to the availability. This study involved patients undergoing skull radiographic examinations in the emergency department at Khartoum Teaching Hospital. The radiographic equipment used Toshiba imaging system. It has a Polydoros LX 50 Lite high frequency generator with a general radiographic X-ray tube Opti 150/30/50HC. The target angle for the X-ray tube was 12°, and the measured ripple for tube potential will be in the region of 1%. Total filtration for the X-ray system measured as 2.7 mm of aluminum equivalent. Finally, in this study, it was found that doses for skull for the entire examination were higher. The ESDs for conventional radiology were lower in AP than those for lateral projection. Unlike the previous studies, the dose in skull radiography was higher in conventional radiography compared to other techniques. Recently digital and computed radiography are becoming more popular due to the important advantage of digital imaging is cost and access. The image quality met the criteria of the departments for all investigation. The findings of this study are therefore neither completely unexpected nor in contradiction with those of other trials. Therefore the importance of dose optimization during conventional radiology imaging must be considered.

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