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An Indirect Radiation Dose Assessment of Adult Patients Undergoing Lumbosacral Joints and Lumbar Spine Radiological X-Ray Procedures

B. Samaila

Department of physics with electronics, Federal University Birnin Kebbi, Kebbi State, Nigeria, P.M.B 1157

**Author: buhari.samaila@fubk.edu.ng, Tel.: +2347067847629*

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Abstract— Patient dose measurement is an important tool for dose optimization and patient protection in diagnostic radiology. It is to safeguard both the medical personnel and patient from undesirable effect of radiation. The present study examines the entrance surface Dose (ESD) and effective dose of 101 patients undergoing routine lumbar spine and Lumbosacral joint radiographic examinations in two health care centers consisting two radiological units in Kebbi State north-western part of Nigeria. Patient dose were evaluated using an indirect method [CalDose _X 5.0 software] based on exposure factors. The mean ESD of the results were found to be 4. 83 mGy and 7.46 mGy for lumbar spine respectively for SMH and FMC, while mean ESD for Lumbosacral joints were 5.16 mGy and 8.84 mGy respectively for SMH and FMC. Similarly, the mean estimated ED was 0.47mSv and 0.74 mSv for lumbar spine while 0.39 mSv and 0.55mSv for Lumbosacral joint respectively for SMH and FMC. The results obtained in this study were higher than the doses reported in NRPB 2000, Iran 2015 and ARPNSA, 201 but lower than that of Brazil 2008, and Italy 2005 in some health care centers. Same applied to ED the results obtained were greatly higher than those obtained in literatures. The higher doses obtained can be attributed to the use of higher tube load (mAs) during examinations, which shows lack of optimization of exposure settings.

Keywords— Adults, Radiation dose, Entrance skin dose, and effective dose

I. INTRODUCTION

Medical exposures from radiological procedure constitute 50% of the overall radiation dose compared with 15% three decades ago. Diagnostic imaging constitute up to 78% of medical radiological exposure [1]. The advancement in radiographic image acquisition, processing and quality allow the operator to overexpose the patient without having to repeat the radiographs [1]. In Nigeria, although the number of radiological medical procedures is increasing considerably, still few studies were reported regarding patient safety and protection. In addition to that, monitoring is of particular importance because some of the X- ray machines are relatively old, without dosimetric performance parameters such as ESAK. Therefore, it is important to evaluate the patient's safety and protection in radiology departments. The objectives of this study are to evaluate the patient doses during diagnostic radiography procedures [1].

Lumbosacral joint X-ray examination is one of the most frequently required diagnostic procedures used in clinical diagnostic radiology. It is an accepted imaging study for the diagnosis of pathological conditions in both children and adults. However, X-ray has inherent hazards that are of special concern when applied to young children. The Lumbosacral X-ray examination can be carried out quickly and easily in an emergency department. The test can help to diagnose some Lumbosacral conditions. Conventional X-ray diagnosis is a significant source of radiation exposure among the population [1]. Therefore, there is the need for X-ray examinations to be conducted using techniques that keep the patients' exposure as low as possible, without affecting image quality. International commission on radiological protection [2] asserted that radiation is a major risk in diagnostic medical imaging and therapy. The problem is caused by incorrect use of radiography equipment and from unnecessary radiation exposure to patients .International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) provide publications on protection from ionizing radiation. The report- 60 of the ICRP and the Basic Safety Standards that was published by the IAEA, contained three basic principles (justification, optimization, dose limits) related to the radiation protection [3, 4]. Exposure of different dose values for the same clinical examination is a reason to draw attention to this issue. Different dose levels are delivered to patients from different imaging techniques when performing Lumbosacral joint examination. The cancer and the genetic effect probability due to radiation exposure are 5.5% Sv-1 0.2% Sv-1, respectively, based on the linear no-threshold model (LNT) of radiation induced cancer [3]. Previous studies have confirmed that patients' doses in diagnostic

radiology procedures are below the tissue reaction levels, but hereditary and cancer effects cannot be neglected. However, the most important radiation protection problem in the diagnostic imaging is the unnecessary exposure which produces an avoidable risk. The unnecessary use of medical radiological examination has been estimated to be in the range of 10%-50%. Therefore, patient protection from unnecessary exposure to ionizing radiation is recommended [3]. Patient radiation dose screening is an essential part of quality assurance in medical imaging to ensure obtaining high quality diagnostic images with the least possible radiation dose to the patient [1]. The main objective of this study is to assess the patient dose during lumbar spine and Lumbosacral joint examinations hitch arise due to the routine imaging techniques

II. MATERIALS AND METHODS

In all, 101 adult patients were considered for the study. The research was conducted in two public hospitals each using conventional x-ray units equipped with constant potential generators, an x-ray emission angle of 17^0 and total filtration of 2.5 mm Al. An indirect measurement was conducted on two frequently used examinations of lumbar spine and Lumbosacral AP. The entrance Skin and effective Doses were calculated using Caldose_x 5.0 software. The software 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 and effective doses for posture-specific female and a male adult phantoms, using conversion coefficients (CCs) normalized to the INAK, the ESAK or the air kerma area product (AKAP) for examinations frequently performed in x-ray diagnosis. The software requires the user to manually input the patient's age, sex, and select type of examination, posture projections, tube potential, field position and the mAs. The ESAK and BSF determined by software then converted to ESD using an equation below:

$$ESD = ESAK \times BSF \quad (1)$$

The effective dose (ED) is one of the parameters used to assess the relevance of examinations involving ionizing radiation [5]. The ED value was obtained using CALDose_X 5.0. The effective dose based on CALDose_X 5.0 is then the average of the sex-specific weighted doses

$$\text{Effective Dose} = \frac{1}{2}\ [F + M] \quad (2)$$

CALDose_X 5.0 calculates a weighted female dose (F) and a weighted male dose (M) given at the end of the result [5].

III. RESULTS AND DISCUSSION

Diagnostic X- ray imaging gives the largest contribution to the population dose from man-made radiation sources. Patient doses from conventional radiography were given trivial concern due to its low value compared to international radiology and CT imaging [1]. Since the frequency of the performed procedures has augmented and a connection was reported between radiation exposure and cancer incidence, more consideration has been paid to keeping the patient radiation exposure to a low value while maintaining the diagnostic information. The choice of the high voltage, the tube loading and the FFD in this study was done for obtaining good quality according to the different morphology of the patients [6]. Therefore, measurements of patient doses and implementation of dose reduction strategies without loss of diagnostic accuracy are crucial [1].

Table 1: Summary of patients' characteristics and technical parameters selected for the various examinations in the five Government hospitals considered for the study.

Examination	SMH						FMC					
	Min	Med	Mean	Max	Mx/mn	STDEV	Min	Med	Mean	Max	Mx/Mn	STD
Lumbar AP												
Age(years)	30	67	58.6	76	2.53	18.7	20	58	53	80	4.0	22.4
FFD (cm)	100	100	100	100	1	0	100	104	103.5	108	1.08	3.06
FSD(cm)	70	77	76.1	80	1.14	3.68	68	75.5	76.2	87	1.28	6.14
KV	76	78	78	80	1.05	1.41	70	77.5	76.4	80	1.14	3.86
MAs	20	22	22	25	1.25	2.12	25	35.5	35.8	45	1.80	6.76
ESD (mGy)	3.82	5.31	4.83	5.65	1.48	0.88	3.53	7.36	7.46	10.9	3.09	2.30
ED (mSv)	0.39	0.47	0.47	0.54	1.38	0.06	0.43	0.71	0.74	1.03	2.4	0.21
RCI	0.83	1.44	1.51	2.65	3.19	0.71	0.91	3.19	2.91	4.61	5.07	1.21
RCM	0.60	0.93	0.92	1.40	2.33	0.31	0.7	1.8	1.71	2.36	3.37	0.55
L/S AP												
Age(years)	20	50	50	80	4	16.87	25	50	50	78	3.12	15.27
FFD (cm)	100	100	100.89	117.00	1.17	4.57	100	105	106.4	115	1.15	5.71
FSD(cm)	67	80	78.88	95.00	1.42	6.09	70	83	83.1	95	1.11	1.28
KV	70	78	78.15	87.00	1.24	2.88	74	80	82.2	95	1.28	3.99
MAs	18	22	24.42	40.00	2.22	4.76	28	38	37.9	64	2.28	6.47
ESD (mGy)	2.39	4.81	5.16	12.10	5.07	1.91	3.72	7.82	8.84	13.3	3.57	2.31
ED (mSv)	0.19	0.37	0.39	0.74	3.74	0.12	0.39	0.51	0.55	1.29	3.31	0.18
RCI	0.55	2.25	2.31	6.88	12.50	1.13	1.37	3.46	3.46	8.2	5.98	1.31
RCM	0.39	1.10	1.13	3.05	7.82	0.48	0.85	1.64	1.68	3.79	4.46	0.56

Table 2: Comparison of mean ESD [mGy] of two centres with national and international studies

Examination	SMH	FMC	[7] Iran	[8] Australia	[9]	[10] Brazil	[11]Italy
Lumbar Spine	4.83	7.46	9.99	6.00	6.00	2.37	3.14
Lumbosacral	5.16	8.84	--	--	--	--	--

Table 3: Comparison of mean ED [mGy] of two centres with national and international studies

Examination	SMH	FMC	[12]	[13]	[14]	[15]
Lumbar Spine	0.47	0.74	1.67	1.90	0.41	0.38
Lumbosacral	0.39	0.55	--	--	--	--

Discussion

The mean, minimum, maximum, max/min ratio and STDV values of tube potential (kVp), tube loading (mAs), focus - film distance (FFD), Entrance Skin Dose (ESD) and effective dose (ED) for all examinations were calculated using excel spread sheet and recorded as shown in table 1. Large fluctuation of the examination parameters has been established. It can be explained by the discrepancies in the examination protocols adopted by each hospital and the patient size. In this study, the soft ware used standard patients' weights based on the information inserted to it. Table 2 shows the comparison of measured ESD (mGy) among two difference X- ray machines. From the results obtained, there is a wide difference in patients' doses in the hospital considered for individual patients and for each projection, the mean ESD vary greatly from SMH to FMC. From Table 2, the highest ESD (mGy) was also detected during Lumbosacral procedure in FMC due to the high density bony structures and body weight, which necessitates higher exposure factors. Table 2, which compares the obtained ESD with previous studies, illustrates that there is wide variation between previous studies. The dose in this study is quite high compared with previous studies such as [7, 8 & 9] except the study in Brazil [10] and Italy [11]. This dissimilarity could be attributed to exposure factors and patient characteristics such as weight and height. Similarly, table 3 indicates comparison between this study and other studies. The effective Dose results illustrates that there is wide variation between previous studies. The effective dose in this study is quite low compared with previous studies conducted by [12, 13] except the study of [5,14]. All X- ray machines in this study are manually controlled by the technologist according to individual patient characteristics. A range of exposure factors is provided by a senior technologist based on their experiences in image acquisition. The increase in patient doses can be explained by the inadequate selection of technical parameters for exposure. The use of the high kVp technique accompanied by mAs and sufficient beam filtration will reduce the patient entrance dose without compromising the diagnostic findings. Significant dose reduction can be obtained by reducing the field size of the X- ray beam or by using protective shields to restrict the primary radiation to required organs or tissues. Due to technology advancement, the patient radiation dose was decreased by 50% in last two decades. To maintain the dose reduction during the procedures, staff training and regular dose monitoring can improve practice while sustaining patient exposure.

IV. CONCLUSION

Patient dose assessments were carried out for two diagnostic radiographic procedures performed in 2 X-ray units. Patient's doses showed wide variation due to patient characteristic, exposure factors settings and X- ray machine features. Patient dose was comparable between the two hospitals for the two procedures performed. The results obtained indicated that there are still possibilities for dose reduction without loss of image quality in Lumbosacral and lumbar spine x-ray procedures. Conventional radiographic X-ray of Lumbosacral joint and lumbar spine must be performed with high level of training for medical staff due to high dose and main kVp output. Indirect Patient dose assessments are important in order to reduce the complication in dose evaluation and pave the way of defining local diagnostic reference level. All technologists should be well trained in patient dosimetry aspects in Conventional Radiographic systems. Therefore, findings from the present study showed that optimization of technical and clinical factors may lead to a substantial patient dose reduction.

ETHICAL APPROVAL

The author hereby declares that all data collected have been examined and approved by the institution ethics committee and have therefore been performed in accordance with the ethical standards laid down in the approval certificate. All X- ray procedures were performed for justified clinical conditions by a qualified medical radiographers and x-ray technicians.

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REFERENCES

[1] S. Abdelmonei *"Measurement of Patient Radiation Doses during Certain Diagnostic Radiography Procedures"*. British Journal of Medicine & Medical Research **12(5): 1-8 2016**.

[2] ICRP, *"Basic Anatomical and Physiological Data for Use in Radiological Protection"*. Reference Values ICRP Publication **89 (Oxford: Pergamon), 2002.**

[3] International Commission on Radiological Protection [ICRP], *"Radiological Protection and safety in medicine"*. *ICRP publication 73*, a web module produced by committee 3 of the **ICRP 1996.**

[4] International Atomic Energy Agency [IAEA], *"Safety support series No.115: International Basic Safety Standards for protection against ionizing radiation and the safety of radiation sources"* **1996.**

[5] B. Samaila, A. Bello, M. Abbas and B. Maidamma, "*Assessment of Radiation Dose for Adult Patients during Anterior Posterior Pelvic X-ray Examinations"*. International Journal of Advances in Engineering and Management (IJAEM), **Volume 3, Issue 9, pp: 1061-1065, 2021a**

[6] B. Samaila, and A. Bello "*Determination of Radiation Doses Received During Knee Joint X-ray Procedures in Kebbi State, Nigeria"*. *SPR*, **Volume 2, issue 1, pp: 506-510, 2021b**

[7] M. Gholami, A. Maziar, H.R. Khosravi, F. Ebrahimzadeh, and S. Mayahi, *"Diagnostic reference levels (DRLs) for routine X-ray examinations in Lorestan province, Iran"* International Journal of Radiation Research, January. **13(1), pp: 85-90, 2015.**

[8] Australian Radiation Protection and Nuclear Safety Agency, *"Entrance Skin Doses"*. https://radiopaedia.org/articles/entrance-skin-dose, **retrieved on 12th Sept, 2020.**

[9] National Radiological Protection Board (NRPB), *"Radiation Exposure of the UK population"*. **Report R263, 2000**.

[10] O.A. Osibote, and A.CP. Azevedo, *"Estimation of adult patient doses for common diagnostic X-ray examinations in Rio de Janeiro, Brazil"*. Physica Medica, **2(4), pp: 21-28, 2008**.

[11] Gaetano, C., Laura, P., and Carlo, B. (2005). Local Diagnostic Reference Levels In standard X-ray examinations. *Radiation Protection Dosimetry* 113 (1), pp: 54–63.

[12] H.M. Kharita, M.S. Khedr, and K.M. Wannus, "*Survey of patients doses from conventional diagnostic radiographic examination in Syria"*. Available at www.radher.jp **retrieved on 22nd Nov 2020,**

[13] P.R. Durga, and T.D. Seife, *"Radiation Exposure of Patients Undergoing Common Diagnostic X-Ray Examinations in Some Major Hospitals in Visakhapatnam, India"*. Journal of Medical Diagnostic Methods, **1(1), pp: 101-119, 2012**.

[14] O.Kofi, W.G. Samuel, A. Emmanuel, A.A. Adriana, and O.D. Emmanuel, *"Estimation of adult patient doses for selected X-ray diagnostic examinations"*. Journal of Radiation Research and Applied Sciences, **7(1), pp: 459 – 462, 2014.**

[15] K.O. Ernest, and D.Johnson, *"A Survey of Organ Equivalent and Effective Doses from Diagnostic Radiology Procedures"*. ISRN Radiology, **7(2) pp: 1- 9, 2013**.

AUTHOR PROFILE

Mr. B. SAMAILA pursed B.Sc and M.Sc Physics [Nuclear Physics option] from Kebbi State University of Science and Technology Aliero in 2013 and 2022. He is currently working as Lecturer in Department of Physics with electronics from Federal University Birnin Kebbi, Kebbi State Nigeria since 2016. He is a member of Nigeria Institute of Physics since 2020, Life member of Scholars Academic and Scientific Society since 2021 and a member of the NSPS 2021. He has published more than 22 research & review papers in reputed national and international. He attended several conferences, Seminars and workshops. His main research work focuses on Applied Nuclear Physics and medical Physics. He has 7 years of teaching experience and 5 years of research experience.

