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Patient Parameterand the Radiation Dose Estimation of Patients Undergoing Lumbar Spine Radiography in Selected Radio-Diagnostics Center in Lagos State, Nigeria

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Abstract

Radiation dose to organs of 50 adult patients undergoing Lumbar Spine radiography from three selected publichospitals in Lagos State were evaluatedfrom the output generator of their X-ray machine (Radiation Output)using an indirect dosimetricmethodwith some mathematical application relevant to knowledge.Organ and effective dose to thePatients were estimated using dosecal. V2.31 software specific machine data and tissue equivalent values.The organs that were exposed significantly due to LS radiography were stomach, Liver,Adrenal,Pancreas, Spleen, Gallbladder,Heart, Lungs, kidney, testicle, esophagus etc. Stomach recorded the highest dose values of240±1.2μGy,113±0.3μGy and 122±2.1μGy respectively for each of the selected hospitals and the mean of the means value of168.0±7.2μGy for LS(AP) and theLiver also recorded the highest dose value of182± 2.3μGy, 140±1.4μGy and151±1.7μGy respectively for each of the hospitals and the mean of the means value of 157.8±2.5μGy for LS (LAT). Entrance surface dose calculated for all the hospitals were0.44±0.1mGy and 1.06±0.1mSvfor LS(AP) and LS(LAT)which reflected LS(LAT)value as been approximately 2.41 of LS(AP).The effective dose were estimated approximately as 0.051±0.02mSv and 0.021±0.03mSv for LS(AP) and LS(LAT) respectively an approximate factor of 2.43,showing that the overall stochastic health effect of radiation from all the selected centers at a whole averagely depend on the projection of the examination(AP or LAT).Local dose reference limit were equally determined as0.44±0.1mSv and 1.06±0.20mSv for an irradiated mass of 18.7±1.4Kg and 28.5±2.1Kg respectively at 95% confidence limit(P value ≤ 0.05) for LS(AP) and LS(LAT).

Keywords: Radiation Output, Entrance Surface dose/Equivalent dose, Organ dose, Effective dose, Radiation Health effect,Patient dose assessment, Lumbar Spine (LS), Lateral(LAT), Antero-posterior(AP).

1.0 Introduction

The use of X-ray for diagnostic imaging has continued to play a leading and a significant role in spite of other imaging techniques both in developed and developing countries of the world.

However, X-ray examination constitutes the most important man made source of radiation exposure of the world population [1]. Although X-ray procedure is assumed to provide net benefit, the potential for radiation induced injury to the patient exists. Therefore understanding what the absorbed dose is and the factors that affect them become very important [2].

In diagnostic radiology, periodic assessment of patient dose and quality control test of X-ray machines are required and compulsory to ensure compliance with recommendations [3]. The major lesson learned from these assessments is the recognition of the significant variations in the patient dose among the radiological departments for same type of procedure[4] and these variations therefore justify dose measurement in order to optimize the diagnostic practice [5].

Patient dose is often described by the patient entrance surface dose, which is measured on the patient's skin at the center of the X-ray beam while appropriate beam collimator (field size) is considered. An alternative method is to take free-in-air

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measurements without the contribution of backscattered radiation from the patient andthese are expressed in term of incident air kerma (IAK).
Radiation dose to various organs or tissues in the body cannot be measured directly in patients undergoing X-ray examination without the anatomical knowledge of the organs or tissues that constitute and/or exist around the area of exposure (anatomical coordinate) and their radio sensitivity values [6]. These can then be estimated with reasonable accuracy while sufficient reasonable amount of data on the X-ray examination parameters (radiological and patient parameters/anthropometric information) are available [7,8].
Therefore, patient's radiation dose measurement in radiological procedure is an important and indispensable way of assessing the quality of procedure and the determinations of exposure to ionizing radiation and this is equally referred to as patient dose monitoring/assessment [9]. Monitoring of X-ray machine dose to patient during examination equally involved relating the dose to patient with the efficiency of a machine. Efficiency of the machine is therefore inversely related to dose to patient while dose is direct proportionate to the risk to the patient, hence monitoring of patient dose becomes much more imperative in the comparison of interdepartmental quality of procedures, modes of administration and their new techniques [10,11,12].
This study will focus on the entrance surface dose of patients undergoing lumbar spine which is one of the common radio-diagnosis procedures for the equivalent dose estimation. The knowledge of the radio sensitivity value of organs/tissues as determined in the computer base program software (Dose cal. Version 2.31) will be applied for the effective dose estimation of both the Lumbar Spine (AP) and (LAT) views.

2.0 Materials and Methods

This study was carried out in three selected public hospitals in Lagos State within secondary and tertiary level using X-ray machines. The machine data and hospital personnel distributions are presented in Tables 1and 2.

Table 1: X- rayfacility machine specific data

Hospitals	Manufacturer	Model/type	Year of manufacture	Year of installation	Filtration length (mmAl)	Tube current(mA)	Film type
H_1	Trex crop of America	Trex with smart UPS 2200	2000*6	Jan, 2001	2.5	300	AGFA
H_2	System Ag medical solution PEG, Germany	System multi swings. s/no 4121	2007*2	April 2009	2.5	400	RETINA
H_3	Micro-medical Co, Japan	Varian-medical X-ray machine	2005*9	March, 2007	2.5	400	Kodak & AGFA

H_1-Orile-Agege General Hospital, H_2 - General Hospital, Gbagada (Lasuth Annex) and H_3-Lagos University Teaching Hospital(LUTH)

Table 2: Distribution of the Hospital personnel

Hospital	Radiographer	Radiologist
H_1	2	1 (Resident)
H_2	1	1 (Visiting)
H_3	16	6 (Resident)

Fifty (50) adult patients aged 18years and above undergoing Lumbar Spine radiography were randomly considered for this study. The examinations were performed by qualified radiographers and the image quality of the exposure was passed by a consultant radiologist at the different hospitals. The examination equally considered the lumbar spine (LS) antero- posterior (AP) and the lateral (LA) performed on a patient.

PATIENT DOSE MEASUREMENT

Free- in- air measurement was carried out using calibrated x-ray test device(Noninvasive evaluation of radiation output by Victoreen Inc. USA) 6000kv meter equivalent placed at1 meter away from the focal spot of the x-ray tube, were made as an alternative for the use of thermo luminescence dose meter (TLD) or any other direct measuring devices.
The measurement of radiation at different tube potential (kV) and a constant current- time product (mAs) value of 10 were taken and recorded at different meaningful range available on the machines.
Adequate conversions were carried out on the recorded output measurements in millirontgen (mR), using 0.00873mGy in air as an equivalent of 1mR for x-ray or gamma and these were divided by the current- time product (mAs) for normalization purposes, obtaining their output ratio (mGy/mAs).These was plotted against the varying tube voltage (iemGy/mAs against kV) to obtain the incident air kerma (IAK) curve for each of the hospital's X-ray machine.

IAK CURVE FOR THE SELECTED HOSPITAL X-RAY MACHINE

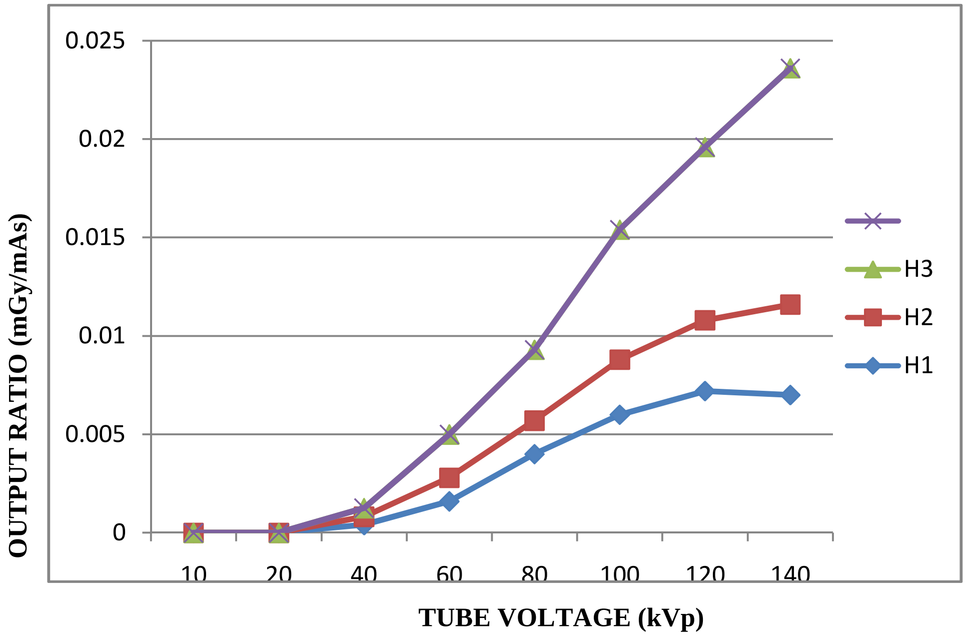

Fig. 1: Incidence air kerma (IAK) curve for the selected centers X-ray machine

Since emphasis has been on estimating from the patient parameters using theoretical approach, the incident air Kerma (IAK) on top of the patient was evaluated using the following equation with a known focus to skin distance (FSD) and the mAs per examination [13].

IAK (kV, mAs) = {(Output(mGy)/mAs) x(FFD/FSD)^{2}x mAs} (1)

Where FFD is the solid detector distance from the X-ray tube focal spot measured on the X-ray table top and FSD is the patients' skin distance from the focal spot of the X-ray machine as measured using tape meter rule capable of measuring at least 0.1cm (1mm) to patients' skin surface.

All relevant radiological and patients' parameter were adequately recorded during the examination for estimation purpose.

Coordinate geometry system approach was applied on the measureable parameter taken from the patients directly during examination with special reference to the equivalent diameter of a reference man which was given as 22.9cm [14,15], normalized the dose of any patient to reference man dose, on the assumption that a patient is a cylindrical tank of water and the equivalent diameter (D_{eq}) were been calculated from the patient's weight and height. The thickness of the patient was therefore considered to be the equivalent diameter of the patient at the antero-posterior position. The thickness wastherefore calculated using the mathematical relationas

$$\boldsymbol{C_{AP} = 2\left(\sqrt{\frac{W}{\pi H}}\right)} \qquad (2)$$

Weight (w), height (H) and AP thickness equivalent (C_{AP}) was represented in gramme (g) and centimeter (cm) respectively. The mass of the irradiated area were equally determined, since the area radiated is an elemental unit of the body component (compound) which was denoted by 'm_i' and the mass of the whole body as the weight of the patient M are equally represented. The weighting factors for each exposed tissue/organ within the irradiated region were added and represented as

$$W_i = {m_i}/{M} \qquad (3)$$

Where W_i is the total radiosensitivity weighting factor for the area irradiated (i.e.$\sum w_{AP}$=0.275, $\sum w_{LAT}$=0.42).Therefore,mass of the area exposed during this procedure is given as

$$m_i = MW_i \qquad (4)$$

Area collimatedgiven by the field size on the machine was considered thearea of irradiation. Assuming that the region were uniformly irradiated without any heel effect together with the patient thickness asdetermined in equation(2), then the volume of the irradiate region over the patient will be the same as the volumes of solids of a revolution given by

$$V = \int \pi y^2 \, dx \qquad (4a)$$

If rotatingabout the X-axis through patient's position in line with the orientation of the X-ray beam or its projection,indebt knowledge therefore gives the field size measurement according to the assumptionthat patient is a cylinder of water [14, 15, 16] and the equivalent diameter of the reference man revolvedaround 'X and Y'- directions for c=z to be constantfor AP and inrotating about Y-axis, through z=c with X-direction constant for Lateral (LAT) given by

$$\boldsymbol{V = \int 2\pi xy dx} \qquad 4(b)$$

Reference to equation (4a)and(4b), equation (5)then represent the volume over patient asa multiple integral considered for the measurable length of the patients' thickness and the field size used during exposure.

$$V = \int Adx \ = \ \iiint dxdydz \qquad (5)$$

Wheredx,dyanddz are elemental changes in the anatomical coordinate of the area exposedon the patient while z= **c** and A = dxdy. The density of the irradiated region as determined from the patient parameters is given by

$$\rho \ = \ {}^{\mathrm{m}}\!/_{\mathrm{v}} \ = \mathrm{m}((\int \mathrm{Adx})^{-1})) \ = \ \mathrm{m}(\iiint(\mathrm{dxdydz})^{-1}) \qquad (6)$$

Where A is the field sizes determined on the machine adjustment during examination, the total linear attenuation of the machine used during examination is given as

$$\mu = \mu_{\mathrm{m}}\rho = {}^{1}\!/_{\mathrm{m}(\iint \mathrm{dydx})} \, [\mathrm{m}(\iiint \mathrm{dxdydz})^{-1}] \qquad (7)$$

$$\mu = \ \left[\left({}^{\mathrm{A}}\!/_{\mathrm{m}}\right)\mathrm{m}(\int \mathrm{Adx})^{-1}\right] = [(\mathrm{Am}^{-1})(\mathrm{m}(\int \mathrm{Adx})^{-1})] \qquad (8)$$

whereμ_m is given as the body mass attenuation given as area per mass of the region uniformly irradiated.

Previous physiological and biomedical studies has revealedwater content in the body to form about(60-70)% of the total body weightand also water as one of the important shielding properties within the body system, as such the Half value layer with reference to the body is determined using the expression

$$\mathrm{HVL} = {}^{-(\ln\,(0.5))}\!/_{10\mu} \qquad (9)$$

Since the filtration length is measured in mmAl.

$\boldsymbol{H_T} = \sum \boldsymbol{D_R W_R}$($W_R$: weighting factor for X-ray is 1), therefore equivalent dose becomes equal to the amount of ionization as defined in Bragg's principle, hence the Entrance skin surface dose was determine using

$$\mathrm{H_T} = \mathrm{ESD_{rad}} = \mathrm{IAK} \times \left({}^{\mathrm{kV}}\!/_{80}\right)^2 \qquad (10)$$

The linearity of the patients' parameter to dose estimation was tested using the expression given below as

$$D = \ D_0 e^{-\mu x} \qquad (11)$$

Which showslinearity with the equation

$$lnD + \ \mu x = lnD_0 \qquad (12)$$

Organ and effective dose to patients undergoing lumbar spine radiography was estimated using dosecal.V2.31 computer base software developed by the radiological protection center,St.George's hospital in London and this program used computational hermaphrodite phantom defined by mathematical expressions to compute organ and effective dose to patient of different ages and sizes in a freely adjustable X-ray projections and other radiological examinations. The organ and effective doses to patients were estimated by inputting ESD, clinically loaded kV,mAs and focus to skin distance (FSD), Patients' weight, age, examination required for diagnosis and the projection of the X-ray beam.Organ and effective doses calculated with this software were adequately compared to those using ICRP'1990publication 60 recommendations (8,15).

3.0 Results and Discussion

This study considered only the Lumbar Spine carried out on a patient (i.e.bothAnteroposterior(AP) and Lateral(LAT) view).

Table 3: Patientmeans anthropometricinformation with range fromthe selected Hospitals

HOSPITAL	AGE (yrs)	WEIGHT (kg)	HEIGHT (cm)
H_1	47.8(34 - 56)	72.1(34 - 56)	165.0(159 - 169)
H_2	44.3 (18 - 68)	56.0 (46 - 62)	166.2(161.5 - 168.5)
H_3	47.8 (43 - 53)	75.6(69.8–80.5)	167.6 (163 – 171.5)
ALL	46. 6(18 - 68)	67.9(46 – 80.5)	166.3 (159 - 171.5)

The anthropometric information's from all the selected hospitals revealed average patients age, weight and height with their range as 47.8 (34 - 56)yrs., 72.1 (69.5 – 73.5)kg, 165 (159 - 169) for H_1, 44.3 (13 - 68)yrs., 56 (46 - 62)kg , 166.2 (161.5 – 168.5)cm for H_2 and 47.8 (43 - 53)yrs., 75.6 (69.8 – 80.5)kg and 167.6 (163-s171.5)cm for H_3 and a single data generated for all these hospitals revealed the following average values as 46.6 (13 - 68) yrs., 67.9 (46-80.5)kg and 166.3 (159 – 171.5)cm respectively for their age, weight and height as shows in table 3.The average filtration usedby all the selected hospitals in this study rangebetween (1.3 – 1.7)mmAl approximately for both AP and LAT for all the peak tube voltage range. The area of collimation(field size) on top of the patientwas averagely calculatedto be 1101(38.22x28.8) and1263(43.0x29.37) cm^2respectively for both AP and LAT view for all the selected hospitals.

Table 4a: Details of theaverage exposure factors with range in parenthesis used in hospital H_1 during examination

Parameters	AP	LAT
kVp	90.0 (90 - 90)	96.0 (90 - 98)
mAS	80.7(80.6 - 81)	92.1(90.5 - 92.5)
FFD(cm)	100 (100 - 100)	100 (100 - 100)
FSD (cm)	76.0(73.4-79.5)	61.5(58.9-65.0)

Table 4b: Details of theaverage exposure factors with range in parenthesis used in hospital H_2 during examination

Parameters	AP	LAT
kVp	84.0 (81 - 90)	85.6 (77 - 90)
mAS	35.0 (25 - 40)	67.7 (40 100)
FFD(cm)	100 (100-100)	100 (100-100)
FSD (cm)	79.6 (73.5-81.0)	65.1(59.0-67.5)

Table 4c: Details of the average exposure factors with range in parenthesis used in hospital H_3 during examination

Parameters	AP	LAT
kVp	82.0 (82 - 82)	99.3 (98 - 101)
mAS	28.3 (21.5 - 36.5)	37. 8 (36.5 - 38 . 5)
FFD (cm)	100 (100 - 100)	100 (100 - 100)
FSD(cm)	76.1(74.2-78.6)	65.3(59.7-64,1)

Table 4d: Details of the mean of the means exposure factors with range in parenthesis used in all the hospitals of study during examination (ALL)

Parameters	AP	LAT
KVp	85.3 (81 - 90)	93.6 (77 - 101)
mAS	48.0 (21.5 - 81)	65.9 (40 - 100)
FFD (cm)	100 (100 -1090)	100 (100 - 100)
FSD(cm)	77.2(73.4-81.0)	64.0(58.9-67.5)

The kVp used for LAT examinations were generally higher than that of the AP examinations, though the differences in the values was not so significant in H_1& H_2 (90.0 – 96.0)&(84.0 – 85.6) compared to H_3 (82.0- 99.3), averagely as a factor of1.07, 1.02 and 1.21 for LAT:AP respectively as reflected in their respective Table. Also the current-time product (mAs) used for LAT shows a significant difference in all the hospitals especially in H_2, compared to AP as an average factor of 1.14, 1.93 and 1.34 respectively forH_1, H_2& H_3.

Table 5a: Details of the average calculated values for the irradiatedregion for LS (AP) for of the eachselected centers

HOSPITALS	CALC. VALUES OF THE IRRADIATED REGION FOR LS(AP)				
	MASS[m_i(kg)]	THICKNESS(cm)	VOLUME(cm^3)	DENSITY(g/cm^3)	MASS ATTENUATN(cm^2/g
H_I	19.83	23.99	25998.6	0.770	0.055
H_2	15.40	20.42	22450.3	0.690	0.071
H_3	20.79	23.95	27382.7	0.760	0.055

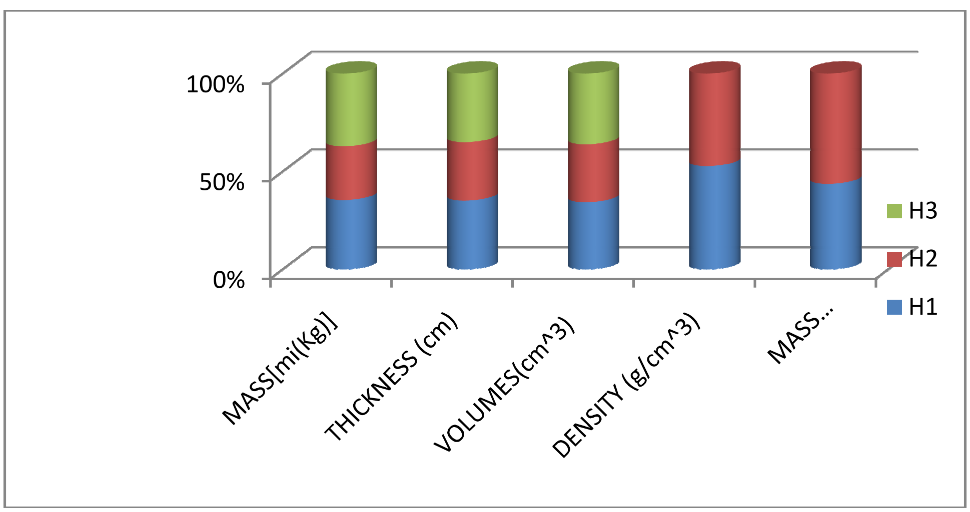

Fig.2: showing the details of the irradiated region calculated for each of the selected hospitals in LS (AP)

Table 5b: Details of the average calculated values for the irradiated region for LS (LAT) in each of the selected hospitals

HOSPITALS	CALCULATED VALUES OF THE IRRADIATED REGION FOR LS(LAT)				
	MASS	THICKNESS	VOLUME	DENSITY	MASS ATTENUATION
H_1	30.28	23.99	27603.7	1.100	0.039
H_2	23.52	20.42	28089.5	0.840	0.059
H_3	31.74	23.95	29959.4	1.070	0.039

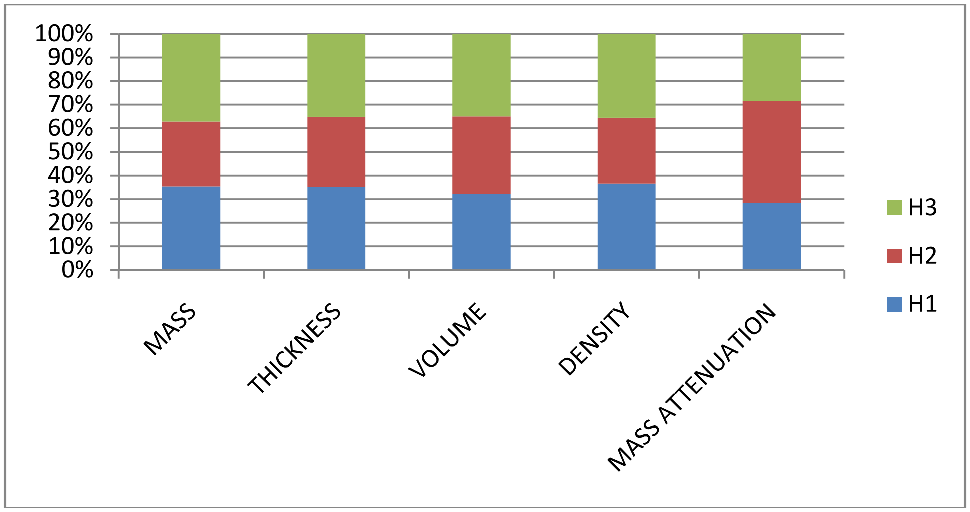

Fig.3: showing the details of the irradiated region calculated for each of the selected centers in LS (LAT)

Table 5c: Details of the mean of the means value of the irradiated region across each of the projections

PROJECTIONS	CALCULATED VALUES OF THE IRRADIATED REGION				
	MASS	THICKNESS	VOLUME	DENSITY	MASS ATTENUATION
AP	18.7±1.4	22.8±1.7	25277±1199	0.74±0.02	0.06±0.002
LAT	28.5±2.1	22.8±1.7	28551±586	1.00±0.07	0.05±0.001

Figures2 and 3revealed those measurable parameters deduced for the irradiated area asequivalent expected values for this type of examination irrespective of the gender while table (5c) shows the expected mean values calculated for the irradiated region at 95% confident limitswith reference to their projections. This is therefore expected to be the limit for the area to be irradiatedfor this type of common procedure.

Table 6: Details of the patients' mean entrance surfacedose with range from each of the selected centers and their respective range factors.

Hospital	AP		LAT	
	Dose±SE /range (mGy)	RF	Dose±SE / Range (mGy)	RF
H_1	0.61±0.0 (0.51 - 0.66)	1.27	1.21±0.2 (0.49 - 1.36)	2.78
H_2	0.33±0.1 (0.13 - 0.46)	3.50	0.99±0.0 (0.47 - 1.08)	2.30
H_3	0.37±0.1 (0.14 – 0.68)	4.60	0.98±0.2 (0.82 - 1.24)	1.51
ALL	0.44±0.1 (0.13 - 0.68)	5.23	1.06±0.2 (0.47 – 1.36)	2.89

Above table 6shows differences in the patient skin equivalent dosebetween AP and LAT and their range factors.It was observed that the range factor for the dose given to patients during AP projection in the selected centers ranged differently as a factors of 1.27, 3.50 and 4.60 respectively for H_1, H_2 and H_3 and also for LAT as 2.78, 2.30 and 1.51 and for all the hospitals it gives an average factors of 5.23 and 2.89 for AP and LAT which shows a reflection of inadequacy in the dose to patient distribution probably due to the radiographer technique or as a result of the variation in the kVpandmAsused, of which it is traceable to the randomly selected patients with varying weight and height. Since high kVp are used for LAT procedure, it is thereforeexpected that the entrance surface air kerma (ESAK) for the procedure (LAT) will be greatly high compare to the AP as supported in some other research studies as a result of increased attenuation in the lateral region.

Table 7: Details of average calculated attenuation for the examination across the selected hospitals

HOSPITAL	AP		LAT	
	μm (cm^2/g)	μ (cm^{-1})	μm(cm^2/g)	μ (cm^{-1})
H_1	0.06±0.0005	0.04±0.0002	0.04±0.0005	0.04±0.0002
H_2	0.07±0.0045	0.05±0.0002	0.06±0.0005	0.05±0.0002
H_3	0.06±0.0045	0.04±0.0002	0.04±0.0005	0.04±0.0002

Table 8: Details of mean effective dose (mSv) calculated 95% confident level for each of the selected centers

Hospital	Ap(mSv)	LAT (mSv)
H_1	0.074±0.01	0.024±0.03
H_2	0.037±0.02	0.017±0.05
H_3	0.041±0.03	0.021±0.02
ALL	0.051±0.02	0.021±0.03

Significant differences is observed in the effective dose presented as shows in the above table for all the selected centers between theexamination's projection(AP:LAT) as a factors of 3.1, 2.2 and 2.0 respectively for H_1,H_2& H_3 and an overall average factor of approximately 2.4 which reflected that the overall radiation health effects on the patient due to lumbar spine AP view is higher than that of the Lateral view and of course contrary to the believes that the radiation effect due to the procedure are independent of the projection (AP & LAT)of the radiation beam and samecan be expected in term of the equivalent dose to organs due to the lumbar spine radiography projection.

Table 9: Details of the meanorgan dose (µGy)calculated for each of the selected centers due to the examination

Organ	Organ dose (µGy)							
	H_1		H_2		H_3		ALL	
	AP	LAT	AP	LAT	AP	LAT	AP	LAT
LUNGS	13.0	6.50	6.10	4.40	6.60	5.50	8.60±0.4	5.50±1.2
LIVER	143.0	182.0	22.9	140.0	81.0	151.0	82.3±6.9	157.8±2.5
STOMACH	240.0	78.0	126.0	50.0	138.0	67.0	168.0±7.2	21.5±2.9
ADRENAL	40.0	49.0	19.0	37.0	20.4	41.0	26.0±1.4	42.3±0.7
KIDNEY	41.0	121.0	20.0	88.0	21.5	101.0	27.5±1.4	103.0±1.9
PANCREAS	114.0	26.0	56.2	18.0	61.1	23.0	77.0±3.7	22.3±0.5
SPLEEN	55.0	6.0	26.90	3.80	29.10	5.30	37.0±1.8	5.1±0.1
GALL BLADDER	220.0	65.0	113.0	45.0	122.0	55.0	152.0±6.9	55.0±1.2
HEART	20.0	45.0	10.0	2.90	10.80	3.90	13.6±0.6	3.80±0.1
SKIN	31.0	42.0	16.70	33.0	18.6	34.0	22.1±0.9	36.3±0.6
SMALL INTESTINE	17.0	61.0	85.3	43.0	93.3	51.0	116.0±5.4	51.7±1.0
URINARY BLADDER	110.0	9.10	54.4	5.9	59.7	7.8	74.7±3.5	7.6±0.2
UTERUS	160.0	32.0	81.0	21.0	88.4	27.0	109.8±5.0	27.0±0.6
ESOPHAGUS	24.0	4.0	11.7	2.6	12.7	3.4	16.1±0.8	3.3±0.1
TRUNK REGION	73.0	56.0	37.1	42.0	40.8	46.0	50.3±2.3	48±0.8
SKELETON	29.0	32.0	14.5	24.0	15.6	27.0	19.8±0.9	27.7±0.5
ACTIVE(RED)MARROW	21.0	29.0	10.2	20.0	11.0	25.0	14.1±0.7	24.7±0.5
TESTICLE	3.1	-----	1.5	------	1.6	------	2.1±0.1	-----------
OVARIES	123.0	64.0	6.2	44.0	6.7	55.0	45.3±7.8	54.3±1.2
UPPER LARGE INTESTINE	200.0	82.0	102.0	58.0	112.0	69.0	138.0±6.2	69.7±1.4
LOWER LARGE INTESTINE	93.0	6.2	46.8	3.9	51.2	5.3	64.0±2.9	5.13±0.1

Total radio sensitivity values for Lumbar Spine AP and LAT as considered in this study are 0.275 and 0.42 respectively [16]. Values presented as: Mean for each of the selected centers and mean± standard for all as mean of the means value,(-)means the value not significant. Population number(N):50 patients. AP: Antero-posterior, LAT: Lateral

The organs recording high doses in each of the selected centeras reflected in this study were presented in table 9. The organ doses then varied across the procedures (AP & LAT) of the radiography (LS) due to the position of the organs with respect to the interaction of the incident radiation on the patient during exposure. It was observed that dose to gall bladder,stomach and the upper large intestine recorded approximately the same values for both lumbar spine radiography in each of the facilities across the procedurewith a factor difference of 1.1and1.2 for AP and 1.1 and 1.3 for LAT respectively for H_1,H_2 and H_3,which might be attached to the patient's presentation during examination with respect to the anatomical position of these organs. Stomachandliverrecorded the highest dose for LS AP and LS LAT radiography respectively. It might be visibly observed that if radio-sensitivity values are used for this organ dose estimation as recommended in the ICRP 103, then organs like stomach, liver, Pancreas, spleen and heart will have recorded more higher dose than as reported in this study by possibly greater fractions while lungs and stomach is expected to record same values due to same radio-sensitivity values (0.12). Testicle and Esophagus recorded lowest dose for LS AP and LS LAT radiography respectively in all the centers. Overall assessment shows that stomach and gall bladder recorded higher but with a non-significant factor difference of1.1 forall AP while also liver and kidney is considered higher for all LAT with factor of 1.5 and dose to skin is seen more higher in lateral of the procedure than it AP. It is expected that there might be a value difference as a factor recorded between the input

Values from thissoftware, Monte Carlo basecomputer software design for this purpose, and the recommended values from ICRP 103.

Further evaluations and deductions from this study mean of the means and appropriate standard error calculated correlated at P (<0.01) are shown in the below tables for possible local diagnostic reference limit determination.

Table 10a: Radiological parameter by examination's projection

EXAMINATIONS	Tube Voltages(kVp)	Current-Time Values (mAs)	Focus to film distance(FFD) (cm)
AP	85.3±2.0	48.0±1.9	100±0.0
LAT	93.6 ±3.4	65.9±1.8	100±0.0

Table 10b: Patient parameter by examinations and their expected amount of ionization for the exposed radiation

Examinations	mass of Irradiated region(Kg)	Patient Thickness(cm)	Field Size area(cm^2)	Volume(m^3)	Density(g/cm^3)	Expected Dose Equivalent (mSv)
AP	18.7±1.4	22.8±1.7	1101±12	25.3±1.2	0.74±0.02	0.05±0.02
LAT	28.5±2.1	22.8±1.7	1263±47	28.6±0.6	1.00±0.07	0.02±0.03

Above revealed the expected radiological and patient parameters for each examinations' projection as determined from the combine cohort of the selected hospitals in the state which might be used as apossible local diagnostics reference limits for adequate and control radiological practice. For every LS(AP) examination of an equivalentmass of irradiated area and field size within the range specified above, a peak voltage and current-time values range of 85.3±2.0 and 48.0±1.9are recommended as the loading valuesrespectively for the above calculated equivalent dose range to be incur while for LS(LAT), 93.6±3.4 and 65.9±1.8 is recommended appropriately for significant mass of irradiated region, patient thickness, volume and density respectively as shown in table10.

Table 11:Details of thecomparisonbetween Entrance Surface doses (ESD) and Entrance surface air kerma(ESAK)from this study with other studies

STUDIES	LUMBAR SPINE RADIOGRAPHY			
	Entrance Surface dose(mGy)		ESAK (mGy)	
	AP	LAT	AP	LAT
H_1	0.61	1.21	0.48	0.84
H_2	0.33	0.99	0.30	0.87
H_3	0.37	0.98	0.35	0.64
ALL	0.44	1.06	0.38	0.78
(13)	0.15	0.45		
(14)	5.1	11.0		
(5)			4.07	8.53

AP = Antero posterior, LAT = Lateral LS= Lumbar spine

The entrance surface dose and the entrance surface air kermarecordedin each of the selectedcenterstogether with the mean of themeans in this study are compared with other studies using appropriate backscatter conversion value as in Table 9. It becomes evident that the average entrance surface doses recorded for both lumbar spine (LS) radiography projections in this study were not high compared to what were recorded in some studies [5, 13, 14]. This might be linked with some fact as number of X-ray facilities considered for the study, differences in the X-ray machine's output,X-ray tube manufacturer and possibly the radiographertechnique. Entrance surface air kerma in this study were far lower compared to (5) for bothprojectionsconsidered for this examination and as such make this study finding consistent with other studies findings.

Therefore, values recorded from this study can be considered at been reasonably control in line with the ICRP recommendations and so be used as a local reference dose for common procedure of this type and also as a representation of the radiological practice in the state.

4.0 Conclusion

All deductions in this study are basically from the patient parameters applying adequate conversion factors with physicist application. The normalized beam output of each X-ray machine used in this study as determined are 0.002556, 0.004010 and 0.005338 for $H_!$,H_2 andH_3 respectively. Organ dose and effective doses due to lumbar spine has been assessed using dose cal. V2.31 software and excel computer base program. It was found averagely in all the facilities considered that stomach and liver received the highest doses for LS AP and LS LAT respectively while testicle and esophagus received the lowest doses.

The effective dose to patients in this procedureLS(APand LAT) recorded a higher significant differences and so definitelysuggest that the overall stochastic health effect of radiation to patient during lumbar spine radiography depends greatly on the projection of the examination (AP or LAT) in all the centers evaluated as a representative of the practice in the state. Local diagnostics reference limit was set at 95% confident level from the analyzed data for adequate and control radio-diagnostics practice in the state as far as the procedure is concern.

5.0 References

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