CHITKARA

Journal of Multidisciplinary Research in Healthcare

Journal homepage: https://jmrh.chitkara.edu.in/

Evaluation of Patient Radiation Doses in Skull Radiography

Chanchal Kaushik[1*], Inderjeet Singh Sandhu[2] and AK Srivastava[3]

[1]*Chitkara School of Health Sciences, Chitkara University, Punjab-140401, India*

[2]*Chitkara University Institute of Engineering & Technology, Chitkara University, Punjab-140401, India*

[3]*Department of Radiology, University College of Medical Sciences, Delhi-110095, India*

*Email: chanchal.kaushik@chitkara.edu.in

ARTICLE INFORMATION

Received: October 12, 2018
Revised: December 20, 2018
Accepted: January 24, 2019
Published Online: April 08, 2019

Keywords:
Quality assurance and quality control, Skull X-ray, digital radiography, entrance surface air kerma, effective dose, diagnostic reference levels

DOI: 10.15415/jmrh.2019.52006

ABSTRACT

Purpose: Exposures to medical ionizing radiations elevate the risk of stochastic effects such as cancer in exposed individuals. It is of utmost importance to monitor the radiation doses delivered to patients and their optimization to reduce the associated radiation risks without limiting the diagnostic information.

Methods: Entrance surface air kerma (ESAK) in a total of 64 adult patients in diagnostic digital X-ray examinations were calculated and effective doses were estimated as per International Atomic Energy Agency (IAEA).

Results: Median ESAK (mGy) and associated effective doses obtained were skull PA (0.45mGy, 0.005mSv) and skull Lat (0.25mGy, 0.003mSv). Results were compared with UK diagnostic reference levels and studies in India.

Conclusion: The comparison revealed that the calculated ESAK and effective dose values were less than the published literature. ESAK values reported in this study could further contribute to establishing LDRLs.

1. Introduction

Medical ionizing exposures elevate the risk of stochastic effects in exposed individuals (Hall *et al.*, 2005). National and international bodies such as National Radiological Protection Board (NRPB), Atomic Energy Regulatory Board (AERB), European Commission (EC), International Atomic Energy Agency (IAEA) and International Commission on Radiological Protection (ICRP) have recommended the establishment of diagnostic reference levels (DRLs) (IAEA, 2005; Hart, 2002; Gray, 2005). They suggest calculation of patient radiation doses and their comparison with DRLs (Vano *et al.*, 2017). DRLs can be local, regional and national. International bodies in radiation protection suggests each country to set up their own DRLs and update them periodically. Also, due to the technological advancements, there has been a shift from the film-screen radiography to the digital radiography (DR) in recent years. DR uses flat panel detectors for capturing the image. DR has its own advantages such as faster acquisition, and contrast adjustment even after the exposure has been made. This creates the need for optimization of patient doses and establishments of guidance levels for radiation protection of patients (Matthews *et al.*, 2009). Doses can be monitored by measuring the kerma area product (KAP) or by calculating the entrance surface air kerma (ESAK). ESAK is measured at a point where X-ray beam enters the patient on the beam axis. It includes the backscatter factor (Zoetelief, 2005; IAEA, 2007). Published literature was reviewed and research gaps showed limited work in dose evaluation in skull radiography, in spite of being the common radiological exam performed (IAEA, 1995). Literature also showed that poor quality skull radiographs were obtained due to low technical standards used and the lack of expertise by the operator and sometimes resulting into repeat exposures. Repeat exposures account to the increased radiation dose (Jennett, 1980; Bell, 1971). The frequency of these examinations is also high (Desmet *et al.*, 1979). Present study aims to calculate the ESAK values and estimate the effective doses in adult patients undergoing

ISSN No.: 2393-8536 (Print) ISSN No.: 2393-8544 (Online) Registration No. : CHAENG/2014/57978

digital skull radiographic examinations. The skull X ray examinations with projection postero-anterior (PA) and lateral (Lat) were considered for the study.

2. Materials and Methods

Total 64 radiographic skull (PA and Lat) examinations were enrolled in the study (27 male and 64 female). Patient doses were calculated with the IAEA protocol (minimum 10 patients per radiographic examination) in a teaching hospital in Delhi, India for a period of 2 months (IAEA, 2007). Weight restriction criteria of 70 ±10 kg was considered and informed consent was taken. In order to compare our doses with other countries, the reference weight of 70 ±10 kg is required. Ethical approval was obtained from institutional ethical committee. A caliper scale was used for measuring patient thickness (t_p). Demographic and technical data i.e., patient's weight, age, height, sex, tube current (mA), mAs, tube voltage (kVp), exposure time (s), patient thickness and focus to detector distance (FDD) was recoded. Patient thickness (measured for each patient) and bucky thickness (5cm) were subtracted from FDD to evaluate FSD. The ESAK was determined (equation 1) as described in international protocols (Gonzalez *et al.*, 2004). Radiographic examinations were performed on digital radiography machine make GE healthcare. X-rays were performed by radiographers on duty. Quality control tests were performed before recording the data.

$$\mathrm{ESAK} = \mathrm{TO} \times (\mathrm{mGy/mAs}) \times \mathrm{mAs} \times (100/\mathrm{FSD})^2 \times \mathrm{BSF} \tag{1}$$

Where,

ESAK : entrance surface air kerma

TO : tube output in mGy/mAs,

mAs : tube current x exposure time,

FSD : the patient thickness and

BSF : the backscatter factor.

The effective dose (equation 2) was evaluated using conversion coefficients from UK HPA -012 (Hart et al., 2010). Descriptive statistics of the collected data were performed in SPSS statistics 23.0 for windows.

$$\mathrm{E}\ (\mathrm{mSv}) = \mathrm{CV}_{\mathrm{ESAK}}\ (\mathrm{mSvmGy}^{-1}) \times \mathrm{ESAK}\ (\mathrm{mGy}) \tag{2}$$

3. Results and Discussion

Demographic information and technical parameters are presented in Table 1. Table 2 presents mean ±SD, median, 25th, and 75th percentile values of ESAK (mGy). It also presents a comparison with 75th percentile values of studies by Bhupendra *et al.* and Satish *et al.* in India, and UK 2010

Table 1: Patient demographic information and technical factors.

Examination		Skull PA	Skull Lat
No. of exposures (n)		30	34
Gender	M	12	15
	F	18	19
age (years)	mean	36.67	35.41
	range	18-52	19-60
Weight(kg)	mean	63.83	65
	range	60-80	60-80
Height (cm)	mean	158	161
	range	140-174	140-170
m A s	mean	4.09	3.24
	range	2.0-7	1.62-5.54
FSD (cm)	mean	76	79
	range	73-83	75-82
Patient thickness (cm)	mean	18.96	16.36
k V	mean	80	70
FDD (cm)	mean	100	100

Table 2: ESAK (mGy) values obtained in the study and comparison with published literature.

This study Examination	ESAK (mGy)					UK 2010	Bhupendra et al. 2018	Satish et al. 2017
	mean ± SD	Min- max	25 percentile	Median	75 percentile	HPA-034	India	India
						75th Percentile		
Skull PA	0.471 ± 0.125	0.272-0.848	0.387	0.454	0.55	1.8	**	4.7
Skull Lat	0.263 ± 0.077	0.133-0.441	0.192	0.252	0.324	1.1	2.38	**

Table 3: Effective Dose, E (mSv) in present study and comparison with UK 2011.

This study Examination	Effective Dose, E(mSv)					UK 2011
	mean	SD	Min-max	Median	75 percentile	mean
Skull PA	0.0061	0.0016	0.0035 - 0.0110	0.0059	0.0071	0.02
Skull Lat	0.0031	0.0009	0.0015 - 0.0052	0.003	0.0038	0.016

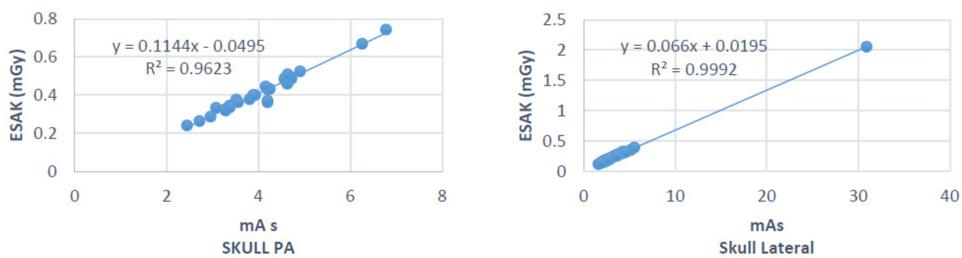

Figure 1: The relationship (linear) between mAs and ESAK (mGy)

review (Rana, 2018; Uniyal, 2017; Hart, 2010). Table 3 presents the effective doses its comparison with mean doses of UK 2011. The linear relationship observed between mAs and ESAK is presented in figure 1 with R^2 values. R^2 values calculated were 0.9623 and 0.9992 for skull PA, skull Lat.

The ESAK values of skull PA and skull LAT are lower in comparison with earlier studies. On comparing doses of present study with UK HPA-CRCE-034, the percentage decrease of radiation dose is found to be 69% and 70% for skull PA and skull Lat. UK report HPA-CRCE-034 is a national survey with the mean patient weight of UK of 70kg (Hart *et al.*, 2010). Our study presents ESAK values in digital radiography. The mean kVp, mAs, tube filtration (mm Al) used for radiographic examinations in UK HPA-CRCE-034 are skull PA (72kvp, 20mAs) and skull Lat (66kvp, 11mAs). It can be seen that a lower mAs is applied in present study for skull PA and skull Lat. Digital radiography uses flat panel detectors, which results in dose reduction (Hernamm *et al.*, 2002). This reduction in patient dose by using flat panel detectors is also reported by Sjoholm *et al.,* and Metaxas *et al.,* (Sjöholm, 2005; Metxas, 2019). Comparing present study results with similar study in India by Bhupinder *et al*, it is observed that for skull Lat the percentage decrease of radiation dose is found to be 86% (Rana *et al.*, 2018). The mean patient weight of both the studies is comparable. Satish *et al.,* presented DRLs via dose survey of mixed type of X-ray machines. For skull PA, the percentage decrease of radiation dose is found to be 88% (Uniyal *et al.,* 2017). Doses below DRLs indicates radiographic practice in acceptable limits, but dose audits are required to maintain ALARA. Present study provides initial baseline data for radiation protection and optimization of doses and suggests timely dose audits in digital radiography.

Limitations: Radiation dose assessment was carried out in skull radiography in present study. ESAK values could further be measured in other common radiographic examinations.

Conclusion

The study aimed to calculate the ESAK, and effective dose values in digital skull radiographic examinations. The results obtained are compared with ESAK and effective dose values of UK and studies in India. Study also presents the current radiographic practices in skull digital radiography. The obtained doses are lower than that of published literature which is attributed to DR system, good radiographic practices and application of dose reduction techniques. Consistent dose optimization can be achieved by timely dose audits. The values obtained in this study may further contribute to future LDRLs.

Conflict of interest: The authors declare no conflict of interest.

Funding source: None

References

Atomic energy Regulatory Board (2001). Safety Code for medical diagnostic X-ray equipment and installation.

No. AERB/SC/MED-2 (Rev.1) (Mumbai, India: atomic energy regulatory board).

Atomic energy Regulatory Board (2016). Safety code for radiation safety in manufacture, supply and use of medical diagnostic X-ray equipment. No. AERB/RFMED/SC-3 (Rev. 2).

Bell R.S. & Loop J.W. (1971). The utility and futility of radiographic skull examination for trauma. *New England Journal of Medicine,* 284(5), 236-239. https://doi.org/10.1056/NEJM197102042840504

Hart, D., Hillier, M.C. & Wall, B.F. (2007). Doses to patients from radiographic and fluoroscopic X-ray imaging procedures in the UK—2005 review HPA-RPD-029. HPA ISBN: 978-0-85951-600-6.

De Gonzalez, A.B. & Darby, S. (2004). Risk of cancer from diagnostic X-rays: estimates for the UK and 14 other countries. *The lancet,* 363(9406), 345-351. https://doi.org/10.1016/S0140-6736(04)15433-0

DeSMET, A.A., Fryback, D.G. & Thornbury, J.R. (1979). A second look at the utility of radiographic skull examination for trauma. *American Journal of Roentgenology,* 132(1), 95-99. https://doi.org/10.2214/ajr.132.1.95

European Commission (EC) (2014). Diagnostic Reference Levels in Thirty-six European Countries Part 2/2. Radiation protection No. 180. Luxembourg: Publications Office of the European Union.

Gray, J.E., Archer, B.R., Butler, P.F., Hobbs, B.B., Mettler, F.A., Pizzutiello, R.J., Schueler, B.A., Strauss, K.J., Suleiman, O.H. & Yaffe, M.J. (2005). Reference values for diagnostic radiology: application and impact. *Radiology*, 235(2), 354-358. https://doi.org/10.1148/radiol.2352020016

Hall, E.J. & Brenner, D.J. (2008). Cancer risks from diagnostic radiology. *The British journal of radiology,* 81(965), 362-378. https://doi.org/10.1259/bjr/01948454

Hart, D., Hillier, M.C. & Wall, B.F. (2002). Doses to patients from medical X-ray examinations in the UK-2000 review. Chilton, UK. National Radiological Protection Board.

Hart, D., Wall, B.F., Hillier, M.C. & Shrimpton, P.C. (2010). Frequency and collective dose for medical and dental X-ray examinations in the UK, 2008. Health Protection Agency.

Hart, D., Hillier, M. & Shrimpton, P. (2010). Doses to patients from radiographic and fluoroscopic X-ray imaging procedures in the UK. Chilton: Health Protection Agency Centre for Radiation, Chemical and Environmental Hazards.

Herrmann, K., Bonel, H., Stäbler, A., Kulinna, C., Glaser, C., Holzknecht, N., Geiger, B., Schätzl, M. & Reiser, M. (2002). Chest imaging with flat-panel detector at low and standard doses: comparison with storage phosphor technology in normal patients. *European radiology*, 12(2), 385-390. https://doi.org/10.1007/s00330-001-1166-4

International Atomic Energy Agency (IAEA) (2007). Dosimetry in diagnostic radiology: An International Code of Practice IAEATRS. No 457. Vienna: IAEA (2007).

International Atomic Energy Agency (IAEA) (2004). Optimization of the radiological protection of patients undergoing radiography, fluoroscopy and computed tomography. Vienna. IAEA (2004).

International Atomic Energy Agency (IAEA) (1995). Radiation doses in diagnostic radiology and methods for dose reduction. IAEA-TECDOC-796. Vienna: IAEA, (1995).

Jennett, B. (1980). Skull X-rays after recent head injury. *Clinical radiology*, 31(4), 463-469. https://doi.org/10.1016/S0009-9260(80)80195-4

Martin, C. J. (2007). The importance of radiation quality for optimisation in radiology: *Biomedical Imaging and Intervention Journal,* 3(2), e38. https://doi.org/10.2349/biij.3.2.e38

Matthews, K. & Brennan, P.C. (2009). The application of diagnostic reference levels: General principles and an Irish perspective. *Radiography*, 15(2), 171-178. https://doi.org/10.1016/j.radi.2008.03.001

Metaxas, V.I., Messaris, G.A., Lekatou, A.N., Petsas, T.G. & Panayiotakism, G.S. (2019). Patient doses in common diagnostic X-ray examinations. *Radiation protection dosimetry*, 184(1), 12-27. https://doi.org/10.1093/rpd/ncy169

Radiation Protection 109 (1999). Guidance on diagnostic reference levels (DRLs) for Medical Exposures. Luxembourg. European Communities: 1999.

Rana, B.S., Kumar, S., Sandhu, I.S. & Singh, N.P. (2018). Dosimetry of Adult And Pediatric Patients For Common Digital Radiography Examinations. *Radiation protection dosimetry,* 179(4), 349-357. https://doi.org/10.1093/rpd/ncx293

Samei, E., Dobbins, I.I.I. J.T., Lo, J.Y. & Tornai, M.P. (2005). A framework for optimising the radiographic technique in digital X-ray imaging. *Radiation Protection Dosimetry,* 114(1-3), 220-229. https://doi.org/10.1093/rpd/nch562

Sjöholm, B., Geijer, H. & Persliden, J. (2005). Impact of digital imaging on radiation doses to the patient during X-ray examination of the urinary tract. *Acta Radiologica*, 46(6), 657-661. https://doi.org/10.1080/02841850510021616

Uffmann, M. & Schaefer-Prokop, C. (2009). Digital radiography: The balance between image quality and required radiation dose. *European Journal of Radiology*, 72(2), 202–208. https://doi.org/10.1016/j.ejrad.2009.05.060

UNSCEAR (2010). Sources and effects of ionizing radiation. 2008 UNSCEAR report to the general assembly with scientific annex.

Uniyal, S.C., Chaturvedi, V., Sharma, S.D. & Raghuvanshi, S. (2017). Estimation of entrance surface air kerma due to diagnostic X-ray examinations of adult patients in Uttarakhand, India and establishment of local diagnostic reference levels. *Australasian physical & engineering sciences in medicine*, 40(3), 687-694. https://doi.org/10.1007/s13246-017-0577-8

Vañó, E., Miller, D.L., Martin, C.J., Rehani, M.M., Kang, K., Rosenstein, M., Ortiz-López, P., Mattsson, S., Padovani, R. & Rogers, A. (2017). ICRP Publication 135. Diagnostic Reference Levels in Medical Imaging. *Annals of the ICRP*, 46(1), 1-144.

Wall, B.F., Haylock, R., Jansen, J.T.M., Hillier, M.C., Hart, D. & Shrimpton, P.C. (2011). Radiation risks from medical X-ray examinations as a function of the age and sex of the patient. Health Protection Agency, Centre for Radiation, Chemical and Environmental Hazards Chilton, Didcot Oxfordshire.

Zoetelief, J., Dance, D.R., Drexler, G., Järvinen, H., Rosenstein, M., Allisy-Roberts, P., Bosmans, H., Moretti, C.J., Van Dam, J., Vañó, E., Wall, B.F., Wambersie, A., DeLuca, P.M. (2005). Patient dosimetry for X rays used in medical imaging. *Journal of the Icru*, 5, 1-113.

CHITKARA

Journal of Multidisciplinary Research in Healthcare

Chitkara University, Saraswati Kendra, SCO 160-161, Sector 9-C,
Chandigarh, 160009, India

Volume 5, Issue 2	**April 2019**	**ISSN 2393-8536**