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Assessment of Radiation Risk During Projection Radiography in a Tertiary Care Hospital, Jaipur.

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ABSTRACT

The objective of this study is to assess the radiation risks in projection radiography by analyzing radiographic or demographic significant variables to establish Diagnostic Reference Levels (DRLs) without reducing image quality. In this study, a Dose Area Product (DAP) meter was used to acquire radiographic data of three hundred adult patients during radiographic projections. All projections were performed by qualified and trained radiographers according to the standard of radiographic projection and exposure factors. Dose results indicate that the skull-AP projection had the lowest recorded DRL value at 0.42 Gy·cm^2, while the lumbar spine-lateral projection had the highest at 2.75 Gy·cm^2. Nevertheless, these DRL values are still lower than those found in earlier research. The DAP meter provides a reliable estimation of DRL values that helps to reduce radiation risks without compromising image quality, and a radiographer plays a crucial role in controlling elements such as exposure factors, collimation, and techniques during projection radiography.

INTRODUCTION

Today, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasonography (USG) are types of advanced modalities available for diagnosis and treatment purposes. However, projection radiography remains an important tool for assessing a wide range of diseases and disorders [1-2]. High standards of rationale and optimization in radiography have been highlighted by several advisory groups and organizations. Multiple studies have yielded a variety of results that may lend credence to improved justification and optimization procedures in this area, despite the International Atomic Energy Agency's (IAEA) observation of a lack of comprehensive quantitative data and audits related to patient safety and security[3].

The International Commission on Radiological Protection (ICRP)-135 publication offers comprehensive recommendations for the safe and effective use of X-ray methods in radiography;

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these results are amply discussed[4]. A variety of optimization strategies are detailed, including correctly immobilizing the patient, using protective shielding effectively, selecting exposure parameters with care, applying additional filtration as needed, utilizing grids, and optimizing image processing techniques in projection radiography. These methods show how many options there are for protecting patients from radiation when they undergo radiographic examination[5, 6]. To maintain high standards of care, radiographers must constantly evaluate their work concerning existing evidence and best practices[7].

Dosimetry is the best method to optimize radiation dose to patients. Therefore, dosimetry is considered in the quality assurance (QA) program, and as a result, dose reference levels (DRL) are achieved easily. This DRL is characterized by two components: dose area product (DAP) and entrance surface dose (ESD)[8, 9]. Initially, routine dosimetry and x-ray instrument quality control programs done in the United States have proven the use of DRLs and their effectiveness in decreasing patient doses during imaging. The results of ESD declined up to 50-70% between the years 1964 to 2004. In different cities or countries, DRLs can be defined as local dose reference levels (LDLs), while nationwide assessment is called national local dose reference levels (NLDLs), but for similar medical imaging procedures, LDLs or NLDLS may be different values [10-12].

Various techniques exist for assessing the ESD, such as employing a DAP meter to quantify the overall radiation exposure considering the irradiated tissue area, utilizing a thermoluminescence dosimeter (TLD) for direct measurement of the administered dose, or a few mathematical empirical formulas[13]. DAP meter is a very simple and useful radiation dose descriptor that provides quick measured radiation doses for patients[14]. The incentive for this study was to compare current practices with results from previous studies by looking at how certain common projection radiography procedures are carried out. This research set out to improve radiographic exams in a Tertiary Care Hospital by analyzing the most frequent procedures and determining where they may be improved[15].

MATERIALS AND METHODS:

This study was carried out at the SMS Hospital, a tertiary hospital located in Jaipur, Rajasthan. Before this study, we performed QA and QC on the X-ray machine (CR system) following Atomic Energy Regulatory Board (AERB) guidelines [16]. We have been selected 300 patients, of whom 180 were male and 120 were female, who had undergone medical imaging from physicians. The physical details, such as patient information (age, sex, height, and weight), exposure settings (kVp, mAs, and distance), and the type of imaging of different body parts (like chest-PA, lumbar spine-AP or Lat, skull-AP or Lat, pelvis-AP) were selected to estimate radiation dose and data collection. All projections were performed by qualified and trained radiographers according to the standard of radiographic projection and exposure factors.

A calibrated DAP meter (KERMAX-Plus SDP, model 120-210) was utilized for this study. It can measure the output of an X-ray tube with an energy range of 40-150 kVp. It could function at pressures ranging from 500 to 1062 hPa, temperatures between -20°C and +50°C, and relative humidity levels between 10% and 90% (without condensation). DAP meter was in two parts: Ionization chamber and DAP reader. The first ionization chamber was affixed underneath the collimator and linked to its reader via a connecting wire to produce readings instantly (1-3 seconds). DAP meter data were measured in $Gy*m^2$ units, but for data analysis and comparison, measured values were transformed into $Gy*cm^2$ units[17, 18].

RESULT:

Three hundred patients' data were collected and analyzed in this study. **Table 1** shows the typical ranges for radiographic and demographic characteristics, such as patient age, weight, height, applied kVp, and mAs.

Table 1: Shows the radiological and patient parameters (Age, weight, height, applied kVp, and mAs). The radiological parameters help to calculate the dose, and patient parameters help to calculate the BMI and body separation.

S. No.	Projection	Number	Age (year)	Patient Weight (Kg)	Height (Cm)	Total Voltage (kVp)	mAs
1.	**Chest PA**	50	36.5(16-62)	56.82(36-75)	165.9(144-199)	59.980(57-64)	10.660(8-13)
2.	**L.S.-AP**	50	36.14(18-60)	56.22(37-70)	166(145-188)	70.0065-75)	41.633(35-50)
3.	**L.S. Lat**	50	36.42(18-60)	56.22(37-70)	166.35(145-189)	75.00(70-80)	56.320(40-65)
4.	**Skull-AP**	50	35.90(17-60)	57.41(40-75)	162.9(140-194)	58.653(56-62)	16.327(13-20)
5.	**Skull-Lat**	50	36.898(17-60)	57.408(40-75)	162.9(140-194)	58.655(56-62)	16.377(13-20)
6.	**Pelvis-AP**	50	36.020(18-16)	56.204(39-70)	166.25(143-195)	70(65-75)	40.653(32-50)

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All six types of projections have their measured average DAP meter values summarized in Table 2.

Table 2: Shows the Mean, SD, minimum, maximum, first quartile, and third quartile of DAP meter values for x-ray examination

S. No.	Projection	Mean	SD	Min	Max	1st Quartile	Median	3rd Quartile
1.	Chest PA	0.44	0.13	0.28	0.60	0.28	0.40	0.59
2.	L.S.-AP	1.10	0.30	0.72	1.53	0.72	1.06	1.53
3.	L.S. Lat	2.16	0.51	1.49	2.75	1.49	2.25	2.75
4.	Skull-AP	0.29	0.10	0.17	0.41	0.17	0.33	0.42
5.	Skull-Lat	0.39	0.12	0.25	0.56	0.25	0.35	0.56
6.	Pelvis-AP	1.56	0.15	1.25	1.87	1.45	1.56	1.58

The skull AP projection had the lowest DAP values, with minimum average, maximum, and third quartile values of 0.17, 0.41, and 0.42 Gy·cm². The lumbar spine lateral projection had the greatest DAP values, with minimum average, maximum, and third quartile values of 1.49, 2.75, and 2.75 Gy·cm². The chest-PA projection is the most important and prescribed x-ray for the patient. In this study, the measured DAP meter values for chest-PA projection were found within range. The minimum of average, maximum, or quartile 3rd values were 0.28, 0.60, and 0.59 Gy*cm^2 for chest-PA projection. **Table 3** summarizes all data of projection radiography of this study and other groups, as Zarghani et al. (2023), Zarghani et al. (2015), Shandiz et al. (2014), Iran (2004), and NRPB (1996) studies.

Table 3: Shows the results of this study, DRLs with other study DRLs

S. No.	Projection	Chest PA	L.S.-AP	L.S. Lat	Skull-AP	Skull-Lat	Pelvis-AP
1.	This Study	0.59	1.53	2.75	0.42	0.56	1.58
2.	Zarghani et al., 2023	-	2.12	3.04	0.38	0.31	1.25
3.	Zarghani and Bahreynl, 2015	0.64	1.99	3.83	1.22	1.01	1.47
4.	Shandiz et al., 2014	0.25	0.7	1.52	0.42	0.39	1.09
5.	Bouzarjomehri et al., 2004	0.97	3.43	8.41	2.85	1.93	3.15
6.	NRPB et al., 1996	1	6	14	3	1.5	4

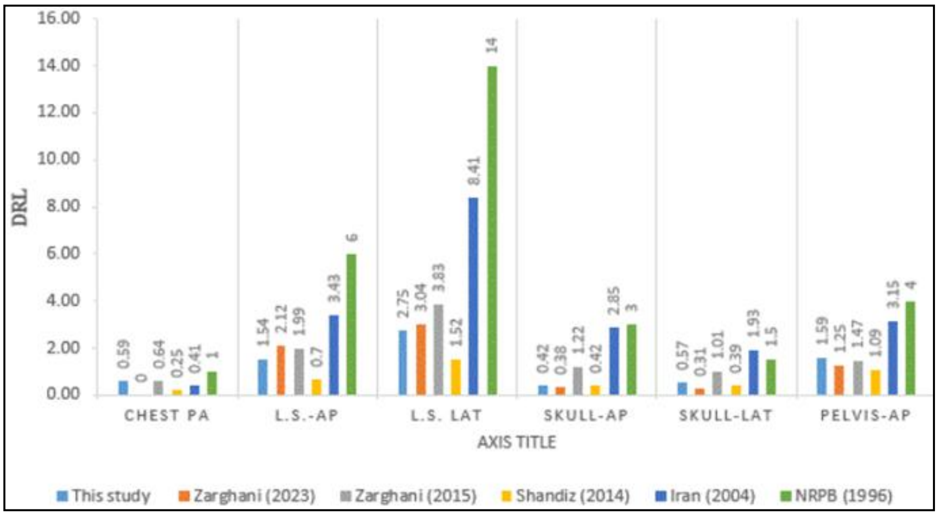

Figure 1: Illustrates the DRL values of this study are closer when compared to other studies

DISCUSSION:

Ionizing radiation produces chemical changes at the cellular level that increase the risk of cancer and other diseases, which are dependent on the radiation type, energy, and exposure duration[19]. In diagnostic radiology, very low radiation doses are used during projection radiography, but according to the AERB, "no dose is safe." From a radiation protection perspective, it is important to monitor and measure the radiation dosage related to every imaging process. Unfortunately, it isn't always easy to access due to a lack of the appropriate dosimetry equipment[20-22]. This research compiles information on the radiation dosages, and the data were compared with national and international DRLs to find and minimize discrepancies and inaccuracies[23-25].

In this study, the DAP meter values obtained from six distinct radiography projections were mostly in agreement with results from related studies. The DRL value for routine chest-PA imaging was 0.59 Gy·cm², whereas the lowest DRL for skull-AP imaging was 0.42 Gy·cm², and in lumbar spine lateral radiography, the highest recorded DRL value was 2.75 Gy·cm². These values were much lower than previous published studies. DAP readings did not significantly correlate with patient variables, including weight, height, sex, or age, but DAP was strongly associated with technical characteristics such as collimation, kilovoltage peak (kVp), and milliampere-seconds (mAs)[26-29]. The radiographer plays a vital role in ensuring dose optimisation during radiography[30]. Through careful selection of exposure parameters, accurate patient positioning, appropriate use of collimation and shielding, and adherence to established protocols, radiographers help minimise unnecessary radiation exposure while maintaining diagnostic image quality. Their ability to make informed decisions in real time based on patient size, clinical indication, and equipment capabilities is essential in balancing image clarity with radiation safety[31].

The results of this study are consistent with the literature, and DRL values can be minimized by periodic QA & QC tests of machines as required, skills of radiographers, following DRLs and guidelines, and using appropriate immobilization devices[32].

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The office of the Ethics Committee granted ethics approval for this study, SMS Medical College and Attached Hospitals, Jaipur. (Reference No: 731/MC/EC/2023).

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