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Analysis of Ovarian Dose Exposure in Adult Female Patients during Chest Radiography

Liambee Alumuku[1*], Joseph Teryima Iortile[2]

[1] Department of Pure and Applied Physics, Federal University P.M.B. 1020 K-Ala Road, Wukari, Nigeria.

[2] Department of Radiology, Benue State University Teaching Hospital, P.M.B. 102131, Makurdi, Benue State, Nigeria.

*** Correspondence:** Liambee Alumuku

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ABSTRACT: The extent of radiation exposure to the ovaries of adult women undertaking thoracic radiographic scrutiny at the Federal Medical Centre Makurdi, Nigeria, has been analyzed to address the issue of radiation safety and associated reproductive health risks through a quantitative methodology. This research evaluates the radiation doses absorbed by the ovaries during standardized chest X-ray protocols. The ovarian radiation doses of twenty female clients undertaking X-ray assessment to investigate their thoracic region have been carefully investigated at an X-ray facility in a Tertiary Medical Institution in Makurdi employing the thermoluminescent dose measurement method. The evaluation was executed utilizing Lithium Fluoride thermoluminescent discs dose detector, with an identification number 4500 HRMP United States of America in conjunction with three-phase and single phase diagnostic X-ray machines. The mean ovarian doses for the female patients under examination were ascertained to be 0.0376± 0.01 mGy. A trend was observed within the dose and tube potential, wherein an increase in tube potential was associated with elevated ovarian dose readings. The findings suggest that ovarian doses remain within acceptable thresholds, approximately representing 3.8% of the 1 mGy reference dose level. Although the investigation indicates that the average dose to the ovaries is considerably within the recommended limits, care must be taken to adhere strictly to the protocols involve as dose to ovaries depends on the parameters.

Keywords: *Radiation dose, scatter radiation, radiation protection, dose exposure and X-rays*

Introduction

Radiological imaging, specifically chest X-rays, constitutes one of the most commonly employed diagnostic modalities in contemporary medical practice (Chest Imaging, 2022). Notwithstanding their extensive utilization, apprehensions regarding the potential biological ramifications associated with ionizing radiation exposure have attracted considerable scrutiny within the medical community (Bakar et al., 2019; Buchberger et al., 2022). This anxiety is particularly salient for reproductive organs, as exposure may result in a spectrum of long-term health repercussions, encompassing infertility and an elevated risk of malignancies. Research indicates that the potential risks associated with radiation exposure during chest radiography warrant careful consideration, especially concerning the ovaries and their role in reproductive health (Hashimoto et al., 2004). The radiation doses absorbed by ovarian tissues, attributable to patient positioning during chest X-ray procedures, engenders significant concerns regarding the equilibrium between diagnostic advantages and possible reproductive threats (Kelsey et al., 2022)

In the context of contemporary medical practice, the utilization of chest X-ray examinations remains pervasive, due to its essential role in the identification of various thoracic conditions. However, the risk of ionizing radiation exposure presents a dichotomous challenge (Bockhold et al., 2022), necessitating a careful consideration of the trade-off between precise diagnostic results and the safety of patients. Ionizing radiation is recognized for its detrimental effects on sensitive tissues, particularly those of the reproductive system (Saleh & Hassan, 2023), thereby heightening concerns regarding the cumulative radiation doses incurred by ovaries throughout these diagnostic interventions (Saueressig et al., 2022).The assessment of ovarian radiation doses during chest X-ray procedures has incited augmented scholarly engagement in recent years. Initial investigations primarily concentrated on the dosimetric evaluations associated with chest X-ray imaging. The advancements in technological capabilities and methodological approaches have facilitated more accurate quantification of radiation exposure to the gonads (Rizzo et al., 2015; Kotian & Panakkal, 2016). Current research now utilize advanced imaging modalities and sophisticated dosimetry instruments to precisely measure exposure, uncovering trends that frequently suggest a wider variability in ovarian doses across distinct demographic cohorts (Phung et al., 2022). Moreover, contemporary studies have shifted focus towards assessing the efficacy of protective strategies employed during these examinations, accentuating the critical role of shielding and patient positioning in the mitigation of doses to reproductive organs. In light of these considerations it is evident that optimizing patient positioning and employing effective shielding techniques can significantly reduce ovarian radiation exposure during chest radiography (Kelaranta et al., 2022). This optimization improves both protection of the client and the preservation of diagnostic utility without compromising reproductive health. Consequently, ongoing research is essential to further elucidate the relationship between radiation exposure and reproductive health outcomes, particularly in female patients undergoing diagnostic imaging (Matsumoto et al., 2021).

A research investigation employing a Rando phantom revealed that at lower tube potentials (60-100 kVp), the radiation dose to the ovaries exhibits an increase corresponding to higher tube potentials (Fung & Gilboy, 2001; Akahane et al., 2021) In contrast, at elevated tube potentials (95-150 kVp), the relationship between gonadal doses and the parameters of the kVp considered was determined to be statistically insignificant. The application of the kVp method resulted in elevated ovary doses relative to the low tube potential technique, with an increase factor of 5.2 when assessing standard exposures at 70 kVp and 120 kVp (Fung & Gilboy, 2001). Another study asserts that the potential risk of genetic repercussions was derived by multiplying the average dosage administered to the ovaries by a risk coefficient of 20. Nevertheless, the study does not provide explicit dosage thresholds for ovarian exposure during computed tomography assessments of the chest. The emphasis is predominantly on the reduction of overall radiation dosage and the estimation of cancer (Mattar, 2022). A comprehensive investigation has demonstrated that the dimensions and orientation of the X-ray field are paramount in influencing the radiation dose received by the ovaries (Martino et al., 2021). Adequate beam collimation and precise alignment serve to mitigate the radiation exposure to reproductive tissues. Conversely, misalignment or the utilization of larger field dimensions may unintentionally elevate the radiation exposure to the ovaries (Skrzypek et al., 2019). In a separate study, it has been ascertained that the application of shielding can substantially diminish the ovarian radiation dose. Shields are capable of safeguarding the ovaries from direct radiation exposure, and augmenting the distance between the X-ray source and the ovaries can further attenuate the dosage received (Nozoe et al., 2022). These strategies are straight forward yet efficacious in reducing radiation exposure.

Currently, there is no much investigation that explores the specific radiation doses taken in by the ovaries concerning the variability of chest thickness among adult female patients. This study, however, is dedicated to the examination of ovarian radiation exposure in adult females during chest X-ray procedures and the parameters that influence these radiation doses. The aim is to establish a thorough comprehension of the radiation exposure received and to assess how standard X-ray protocols may impact female patients. With these findings, healthcare practitioners can become more knowledgeable regarding the timing and necessity of imaging interventions, thereby ensuring that protective measures are effectively implemented, particularly for patients of reproductive age.

2. Materials and Methodology

Investigation took place within the X-ray facility of Radiological area in Makurdi, North central Nigeria. Consent was sought at the facility by letter of introduction from the Department of Physics, Benue State University Makurdi, Nigeria with the principal aim of measuring the scattered X-ray dose to the ovaries during standard posterior-anterior (PA) chest examination conducted at various maximum tube voltages and distances from the source with single phase X-ray machine(Philips Medicals, and model number Practix 33 Plus with maximum kVp of 110 and maximum mAs of 250, manufactured, 2006) and three phase X-rays (Philips, model

PXR 321B, with 125kVp maximum output and 630mAs, manufactured 2018).In pursuit of this objective, a cohort of 20 adult female patients, representing a diverse age spectrum, were randomly selected for radiological chest evaluations due to limited number of TLD badges and the patients that accepted to take part in the study. The ages of the participants ranged from 19 to 69 years. This specific age range was intentionally selected to ascertain that all participants were adults, thereby mitigating any potential confounding effects associated with age on the measurements of radiation dose. The assessment of scattered X-ray dose to the ovaries was conducted utilizing the thermo luminescent dosimeter (TLD) 4500 from Harshaw United State of America with circular shape measurements of 4.5mm and 0.8 as diameter and thickness respectively.TLD discs used for the measurement where calibrated and annealed at National Institute of Radiation Protection and Research Ibadan, Nigeria. Measurements of scattered radiation dose at the gonad region was done by strategically positioning the calibrated TLD discs encapsulated in a synthetic container with a lid placed at the ovaries positions of the female participants that wore changing gown during the investigations. The TLD discs were then retrieved following the chest examination to measure the entry dose. The TLD measurements were subsequently analyzed to ascertain the average scattered radiation dose received by the ovaries.

3. Results

Table 1: Dose investigation at ovaries.

Age(years)	Chest Thickness (inches)	kVp	Mas	FSD (cm)	SSD (cm)	Dose at ovaries (mGy)
49	10.16	70	43	160	143	0.0450
26	10.21	65	50	158	145	0.0369
33	10.57	73	37	166	143	0.0334
47	10.23	71	40	138	130	0.0391
60	10.20	72	31	160	142	0.0450
64	9.80	63	38	143	122	0.0343
30	10.30	72	60	144	126	0.0401
67	9.00	68	37	156	144	0.0342

45	10.90	72	40	123	130	0.0395
56	9.30	62	39	142	148	0.0357
41	9.50	61	34	165	137	0.0371
69	9.70	67	39	163	122	0.0377
51	10.01	70	40	155	127	0.0388
60	9.38	60	32	142	144	0.0352
48	9.50	59	37	137	141	0.0331
38	12.50	73	40	132	145	0.0401
29	9.88	64	39	167	149	0.0382
19	9.35	65	39	140	128	0.0371
62	8.70	58	37	145	134	0.0344
58	10.20	66	39	146	121	0.0374

*FSD- Focus–Skin Distance and SSD- Source Skin Distance

Table 2 Statistical Analysis of key parameters during the analysis

	Chest thickness(inches)	kVp	Mas	Dose absorbed by Ovaries(mGy)	
Mean	**10.13**	**66.47**	**40.42**	**0.0377**	
Standard Deviation	**0.63**	**4.53**	**10.36**	**0.0045**	
Range	**8.70-12.50**	**58-73**	**31-60**	**0.0331-0.0450**	
Correlation Analysis for chest thickness and Dose at ovaries					**r=0.34 p-0.04**
Correlation Analysis for kVp and Dose at ovaries					**r=0.29 p=0.08**
Correlation Analysis for mAs and Dose at ovaries					**r=0.41 p=0.43**

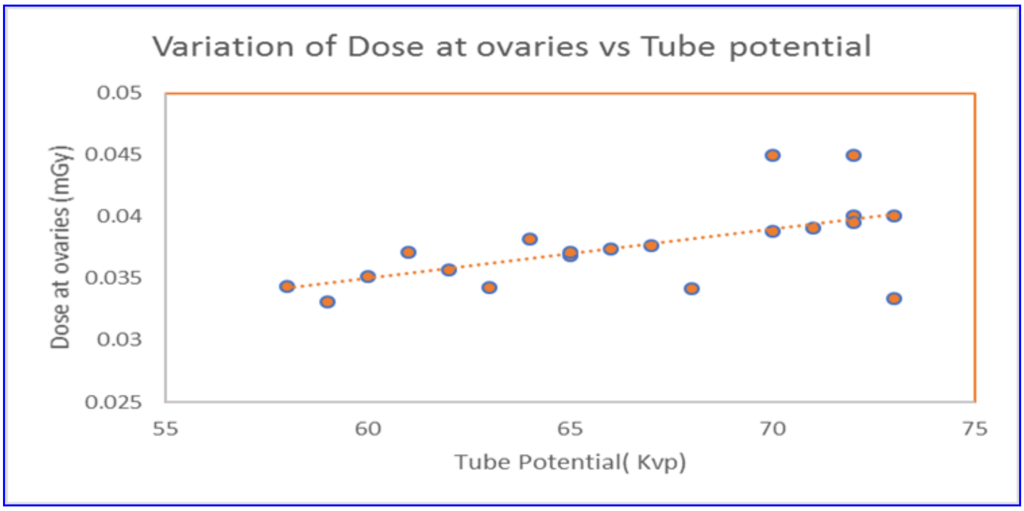

Figure 1: Ovarian Dose (mGy) to Tube potential (kVp)

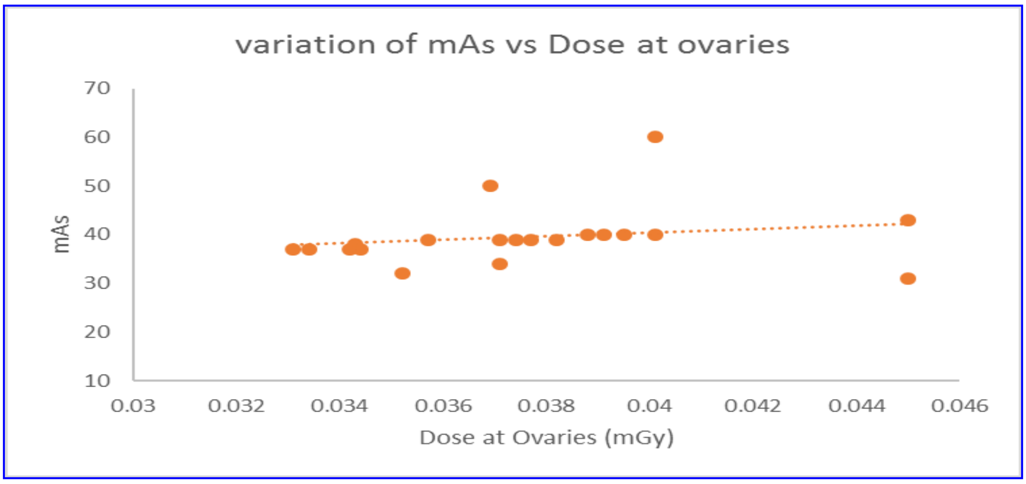

Figure 2: mAs to Ovarian Dose

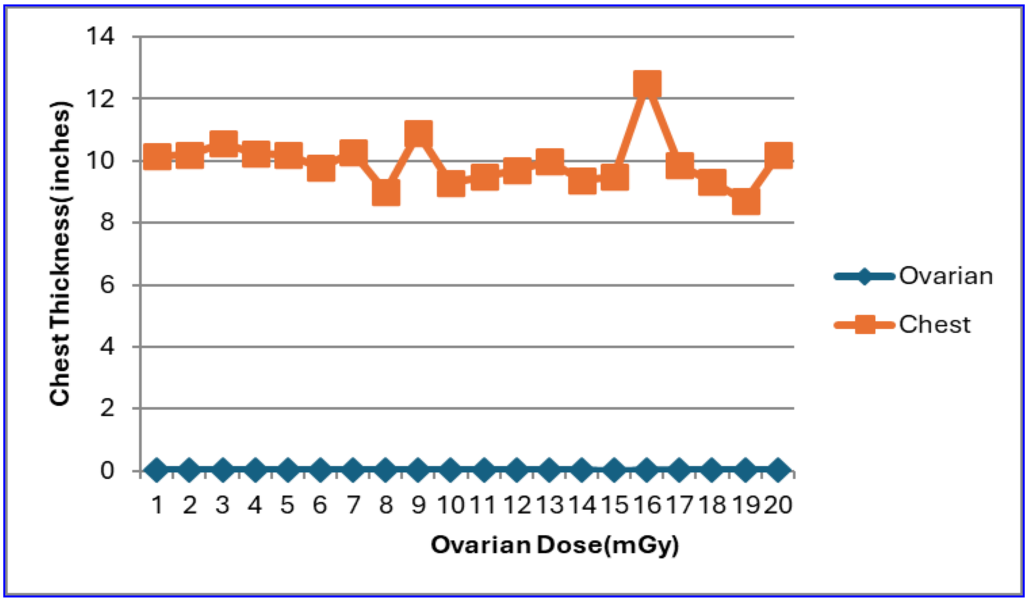

Figure 3: Chest thickness (cm) to Ovarian Dose(mGy)

4. Discussion

The findings derived from this investigation reveal that the radiation doses absorbed by ovarian tissues during adult chest X-ray procedures averaged approximately 0.0376 ± 0.01mGy with a coefficient of determination recorded at 0.43, commonly called R-squared. It illustrates that nearly 43% of the variance in ovarian dose can be linked to shifts in other independent variables. The mean chest thickness is calculated to be 10.13inches, alongside a standard deviation of 0.63inches, spanning from 8.70 inches through 12.50inches. The average kilovolt peak (kVp) extracted from the dataset is documented as 66.47, with a standard deviation of 4.53, and falls within a spectrum of 58 to 73. The mean milliampere-seconds (mAs) is computed to be 40.42, exhibiting a standard deviation of 10.36, with a distribution ranging from 31 to 60. The average absorbed dose to the ovaries, articulated in milligrays (mGy), is recognized as 0.0377, with a standard deviation of 0.0045, and varies from 0.0331 to 0.0450 as summarised in Table 2

Research findings demonstrate a relevant positive connection between chest thickness and the ovarian dosage, illustrated through a correlation coefficient (r) of 0.34 and a p-value of 0.04. The correlation observed between kVp and the ovarian dose reveals an r value of 0.29 alongside a p-value of 0.08, indicating a weak positive relationship. Conversely, a more pronounced moderate positive correlation is observed with mAs, which reveals a correlation coefficient of $r = 0.41$ and a statistically significant p-value of 0.01 pertaining to the ovarian dose. Therefore, the determined R-squared value of 0.43 emphasizes that approximately 43% of the variance in the ovarian dose can be elucidated through variations in other quantified variables.

The outcomes of this study have yielded pertinent insights concerning the kilovolt peak (kVp) and the magnitude of radiation doses absorbed by the ovaries for female patients, respectively, during the patients' chest radiological assessments, as shown in Table 1. Figure 1 illustrates that ovarian radiation doses escalate with an increase in tube potential, corroborating the assertions made by Alumuku et al. (2014) in the context of testicular examinations. This phenomenon takes place because the voltage at its maximum at the X-ray tube improves the energy of the X-ray within the beam, resulting in an increase in the energy absorbed by the gonads due to the augmented scattering capacity of the X-rays. As the tube potential escalates, the energy of the X-rays correspondingly increases, thereby implying that the X-ray beam possesses enhanced penetrating power, capable of traversing greater distances within the body, ultimately culminating in a heightened dose to the ovaries (Amin & Faraj, 2021). Consequently, an increased X-ray quantity will be generated at the point of interest, which in turn amplifies the intensity of the beam, as reported by Zanon et al. (2024).

The utilization of high tube potential in chest radiography is inadvisable, as it administers considerably elevated doses to the ovaries, where the emitted X-rays are dispersed over extended distances (Pengpan et al., 2025). Furthermore, it results in the production of films with diminished contrast, thereby compromising the diagnostic utility is likely to result in reduced ovarian doses during chest radiological examinations (Takagi et al., 2020). It is noteworthy that the ovaries are classified as radiosensitive organs, and faced with large amount of X-ray doses if adequate protocols are not considered. These may increase the risk of genetic damage and oncogenesis (Mohamed et al., 2023); thus, it is crucial to minimize the dosage to the ovaries in times of chest X-ray evaluations. This study further considers the variation in milliampere-seconds (mAs) and the corresponding dose for the ovaries throughout these investigations, as shown in Figure 2, where a significant correlation between mAs and ovarian dose has been established. Specifically, elevated mAs values are associated with increased doses absorbed by the ovaries (Alumuku et al., 2014).

The investigation additionally disclosed that the ovarian doses acquired through thermoluminescent dosimetry (TLD) measurements exhibit a decline in correlation with an increase in chest thickness, as illustrated in Figure 3. These observed patterns imply that the volume of X-rays absorbed by the patients is contingent upon their physical size. As the thickness of the patient's chest increases, there is a greater absorption of X-rays, resulting in a diminished quantity of X-rays being scattered to the ovaries (Somasundaram et al., 2020). A further examination of the ovarian doses was conducted, as the trends reflected in Figures 1-3 appeared to exhibit analogous characteristics.

The measured ovarian dose corresponds with results from studies indicating that smaller radiation doses may induce prolonged repercussions (Leung et al., 2021)(AbdelMalik.et al .2008)The lower ovarian dose corroborates existing research suggesting that female reproductive tissues may exhibit a certain level of resilience in response to analogous radiation exposures (Sullivan & MacKinlay, 2023).

While the ovarian radiation exposures are deemed to be within safe limits, the results from this investigation illuminate the relevance of the radiation dangers when not properly administered.The notable association between tube potential and radiation dose further shows the necessity for meticulous selection of X-ray machine parameters to reduce radiation exposure.

5. Conclusion

These findings advocate for heightened awareness among healthcare practitioners regarding radiation exposure and the imperative for customized radiation protection methodologies. This research contributes to the formulation of evidence-based protocols for radiological practices, highlighting the necessity of proper administration and radiation safety measures to protect the reproductive health of patients undergoing radiological assessment procedures. The cumulative risk is still extremely low, but awareness of dose and use of ALARA are important especially in following the guidelines and X-ray machine specifications. Subsequent investigations should prioritize the examination of radiation exposure levels in additional diagnostic imaging techniques and the establishment of effective approaches to do away radiation risks within clinical settings. Further analyses should also aim to correlate the recorded radiation doses with patient demographics and variations in chest thickness to enhance the comprehension of radiation exposure risks in this demographic group.

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