Gender-wise Variation in the Delivered Radiation Dose during Common X-ray Procedures. A Preliminary Study

DM Satharasinghe [1,2#], WMNMB Wanninayake[2], AS Pallewatte[3] and J Jeyasugiththan[1]

[1]*Department of Nuclear Science, Faculty of Science, University of Colombo, Sri Lanka*
[2]*Horizon Campus, Malabe, Sri Lanka*
[3]*Department of Radiology, National Hospital of Sri Lanka, Colombo, Sri Lanka*

[#]duminda92ms@gmail.com

Abstract - The increased radiosensitivity in women compared to men is a greater concern in diagnostic radiology, which uses ionization radiation for the purpose of diagnosis. However, radiation protection authorities, such as the international commission on radiation protection (ICRP) have only focused on the average adult when giving radiation protection recommendations, such as diagnostic reference levels (DRL). The present study aimed to evaluate the gender wise variation in delivered radiation dose during common X-ray projections. The dose area product (DAP) values of six X-ray projections were recorded for 658 adult patients (393 male and 265 female) of same age range of 18 to 83 years who underwent routine X-rays at two hospitals. A gender wise comparison between the resultant average DAP values showed that the females received a higher mean dose than the males during abdomen anteroposterior (AP) (230.0 µGy.m^2), kidney-ureter-bladder (KUB) (323.8 µGy.m^2) and pelvis AP (268.3 µGy.m^2). In addition, males also received higher doses of 124.1 µGy.m^2, 388.0 µGy.m^2 and 16.3 µGy.m^2 respectively for lumbar spine AP, lateral and chest posteroanterior (PA). However, these differences were significant only in chest PA and lumbar spine lateral projections (P=0.000 and 0.001). Therefore, the authorities should focus on subpopulations rather than consider an average adult when providing dose recommendations and guidelines on radiation protection. However, in-depth and large-scale studies are required to support the idea of gender-based DRLs in the future.

Keywords: X-ray procedures, radiation dose, gender difference, dose area product, DAP, DRL

I. INTRODUCTION

Ionizing radiation is well known for its deleterious effects on human life. The identification of radiation exposure risk is important for the implementation of protective measures. Demographic factors such as age, sex and genetic susceptibility influence radiosensitivity. However, the influence of gender-differences on radiation sensitivity has given less attention compared to other factors. An animal study had proven that there is a gender-related difference in radiation-induced cataractogenesis (Henderson *et al.*, 2009).

Moreover, a controversary exists regarding the long-term risks following the exposure to ionizing radiation during medical diagnosis, particularly in women than men (Institute of Medicine (US) Committee on Women's Health Research., 2010). The Institute of Medicine USA, claims that the ionizing radiation from computed tomography (CT) scan is a contributing factor for breast cancer in women (Smith-Bindman, 2012).

The increased radiosensitivity in women compared to men is a greater concern in diagnostic radiology, which uses ionization radiation for diagnosis. Therefore, it is being highly demanded to have dedicated imaging protocols with a special focus on radiation dose optimization in women. In fact, the international radiation protection authorities such as International Commission on Radiological Protection (ICRP) and International Atomic Energy Agency (IAEA) had given their recommendations for a population average (e.g. for a standard average adult of 70-75 Kg of body weight) without considering the subpopulations (Vañó *et al.,* 2017)(IAEA, 1998). These guidelines includes sensitive radiation protection aspects such as diagnostic reference levels (DRL) which helps in identify abnormally low or high radiation doses that are beyond the clinical requirement. Therefore, in this study we aimed to analyze the gender-wise variation in radiation dose delivered during

common X-ray procedures to determine the validity of using an average adult irrespective of gender in the DRL process.

II. METHODOLOGY

This cross-sectional study was conducted in three X-ray rooms belongs to two hospitals (state-owned (A) and private (B)). The head of the institution of the hospital B and the institutional review board of hospital A waived the individual patient informed consent since patient identification data or their direct involvement was not required for the study. A total of 658 adult patients (393 male and 265 female) of the same age range (18 to 83 years) were included in the study. Patient morphometric data (age and gender) together with dose area product (DAP) were recorded for each patient for six X-ray projections (chest posteroanterior (PA), kidney, ureter and bladder (KUB), abdomen anteroposterior (AP), lumbar spine AP/lateral and pelvis AP). In hospital A, the data collection was done at the site using a commercially available ion chamber manufactured by "Vacu Tec" Germany with dose area product (DAP) resolution of 0.01 μGym^2 and active area of 147x147 mm. In hospital B the DAP values were automatically displayed on the image footer so that no any external device was required for the dose data collection. The statistics were done using Minitab® 17.1.0 statistical software. Independent sample T-test was used to test for the significant differences between the mean DAP values of two gender for different X-ray projections at the level of significance (α) of 0.05. Finally, 11 subjects were excluded from the analysis after identifying them as outliers.

III. DISCUSSION AND ANALYSIS

Assuming equal variances, the obtained P values for the independent sample T-tests which compares the difference in means of DAP of six X-ray projections are given in table 1. The level of significance was kept at 0.05 and the outliers were removed from the samples due to their influence on the calculated statistics. . Figure 1 illustrated the dose distribution using boxplots. According to table 1 and figure 1, it is seen that the females received higher mean dose than that of males during abdomen AP (230.0 μGy.m^2), KUB (323.8 μGy.m^2) and pelvis AP (268.3 μGy.m^2). In addition, males also received a higher dose of 124.1 μGy.m^2, 388.0 μGy.m^2 and 16.3 μGy.m^2 respectively for lumbar spine AP, lateral and chest PA. However, these differences were significant only in chest PA and lumbar spine lateral projections (P=0.000 and 0.001).

Figure 2 (a) and (b) illustrates the distribution of tube potential (kVp) and tube current (mAs) utilization among males and females for the above X-ray projections. The kVp and mAs used for chest PA projection were nearly similar for males and females although the corresponding mean DAP values were significantly different. Since DAP accounts for both dose and the radiation field area, the difference in obtainedDAP values can be attributed to the vriyng X-ray field sizes used for the same projection of the different genders.

Table 1. The mean DAP values obtained for different X-ray projections and the resultant P values after analysing the sample means using the independent sample T test. (α = 0.05)

X-ray	Mean DAP (μGy.m^2)				P value	% change
	(n)	Female	(n)	Male		
Chest PA	126	13.8	202	16.3	0.000	+15.3%
KUB	03	323.8	17	314.5	0.817	-2.95%
Abdomen AP	18	230.0	51	203.6	0.336	-12.96%
Lumbar Spine AP	47	117.8	54	124.1	0.619	+5.07%
Lumbar Spine LAT	50	255.0	61	388.0	0.001	+34.2%
Pelvis AP	10	268.3	08	219.4	0.096	22.29%

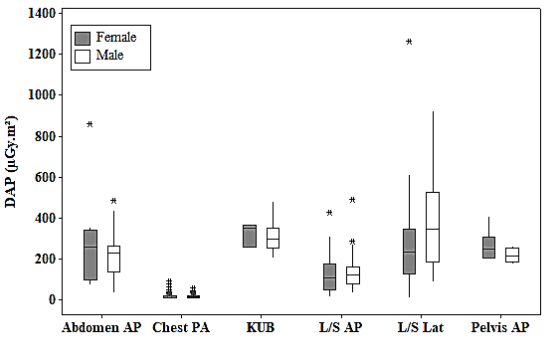

Figure 1. Box and whisker plots illustrates the distribution of DAP values obtained for various projections for males (M) and females (F) separately.

However, a clear difference was seen between the kVp and mAs used for rest of the projections similar to the difference in DAP. This can be attributed to differences in their body sizes where the exposure parameters are adjusted to provide optimum quality image

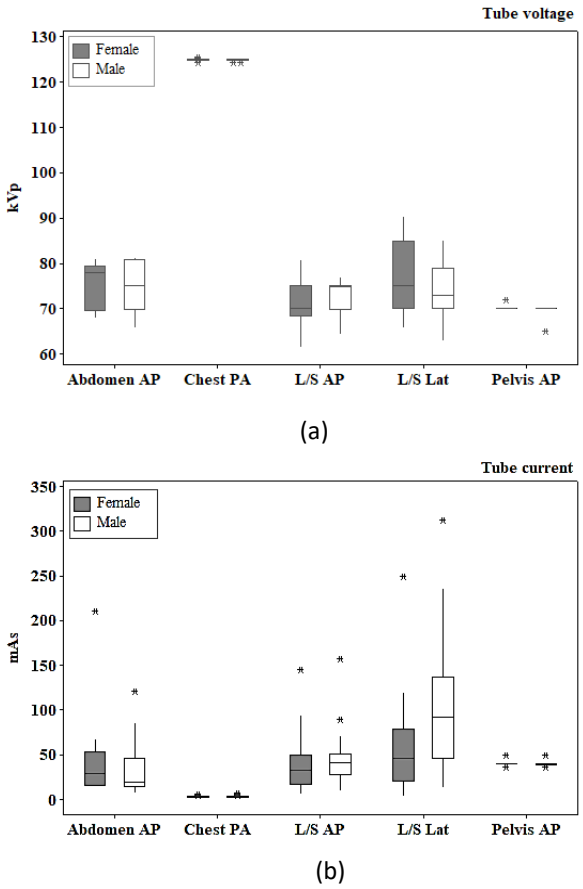

Figure 2. Box and whisker plots illustrates the distribution of (a): tube potential (kVp) and (b): tube current (mAs) utilization for males and females during various projections separately.

The United States nuclear information and resources services (NIRS) data suggest that the radiation risk associated with women is comparatively higher than men since cancer and death incidents reported were 50% higher in women, among men and women who are being exposed to same amount of the radiation (NIRS, 2011). Despite these differences, similar protection standards were still applying for both genders by ICRP and IAEA. The results of the present study, indicates that females received considerably higher doses than males for the same X-ray procedure.

In addition, all the above projections irradiate the most radiosensitive tissues of the female body such as the breasts and ovaries which increase the risk of breast cancer. Breast cancer is the most common cancer among females in Sri Lanka and each year 3000 new cases are diagnosed. Hence the contribution of medical exposures for the above elevation cannot be neglected (Balawardena *et al.,* 2020). Therefore, when providing recommendations, it is essential to consider this gender-wise variation in the radiation dose whenever appropriate

IV. CONCLUSION

The increased radiosensitivity in women compared to men is a greater concern in diagnostic radiology. Therefore, it is being highly demanded to have dedicated imaging protocols with a special focus on radiation dose optimization in women and children, as they do not fall under the reference man. The results of the present study suggest that a gender-wise variation exists among the delivered radiation doses during common X-ray projections. The females received a higher mean dose than that of males during abdomen AP, KUB and pelvis AP that were 230.0, 323.8 and 268.3 $\mu Gy.m^2$ respectively. In addition, males also received a higher dose of 124.1, 388.0 and 16.3 units respectively for lumbar spine AP, lateral and chest PA. However, these differences were significant only in chest PA and lumbar spine lateral projections (P=0.000 and 0.001). Overall, more studies are needed to fully conclude the gender-differences in the delivered radiation dose during X-ray based medical imaging procedures and radiation protection authorities should focus on subpopulation rather than considering an average adult irrespective of gender when giving recommendations and guidelines on radiation protection.

REFERENCES

Balawardena, J. et al. (2020) 'Breast Cancer Survival in Sri Lanka', JCO Global Oncology, (6), pp. 589–599. doi: 10.1200/jgo.20.00003.

Henderson, M. A. et al. (2009) 'Effect of gender on radiation-induced cataractogenesis', Radiation Research, 172(1), pp. 129–133. doi: 10.1667/RR1589.1.

IAEA (1998) Diagnostic Reference Levels (DRLs) | IAEA. Available at: https://www.iaea.org/resources/rpop/health-professionals/radiology/diagnostic-reference-levels (Accessed: 6 May 2021).

Institute of Medicine (US) Committee on Women's Health Research. (2010) Women's Health Research: Progress, Pitfalls, and Promise. Washington (DC): National Academies Press (US). doi: 10.17226/12908.

NIRS (2011) Atomic radiation is more harmful to women. Available at: https://www.nirs.org/atomic-radiation-is-more-harmful-to-women-2/ (Accessed: 14 May 2021).

Smith-Bindman, R. (2012) 'Environmental causes of breast cancer and radiation from medical imaging: Findings from the Institute of Medicine report', Archives of Internal Medicine, pp. 1023–1027. doi: 10.1001/archinternmed.2012.2329.

Vañó, E. et al. (2017) 'ICRP Publication 135: Diagnostic Reference Levels in Medical Imaging', Annals of the ICRP, 46(1), pp. 1–144. doi: 10.1177/0146645317717209.

ACKNWOLEDGEMENT

This work was supported by the project of "Accelerating Higher Education Expansion and Development (AHEAD)" which is a World Bank funded Sri Lankan government operation to support the higher education sector (AHEAD 6026-LK/8743-LK).