Testicular Radiation Dose during KUB Radiography

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***Abstract* —** *Radiographic imaging plays a major role in diagnosing various kinds of diseases and in detecting unknown medical conditions. Ionizing radiation can cause tissue changes starting from cellular level. Genital organs are highly sensitive to ionizing radiation. Hence they are more vulnerable to biological damages following exposure to ionizing radiation. KUB (Kidney, Ureter, Bladder) radiography is a commonly performed radiographic examination where the abdomen is exposed down to the pubic symphysis thereby a significant scatter radiation is likely to be received by the testes being superficially placed organs in the close proximity.*

The objective of this study was to estimate the testicular radiation dose during routine KUB examinations.

Seventy five adult male patients undergoing routine KUB radiographic examinations in Teaching Hospital, Kurunegala were taken into consideration. The Electronic Pocket Dosimeter (EPD) was used to measure the individual testicular radiation dose. A pre-coded questionnaire was used to record the demographic data and the relevant radiographic parameters.

According to the results mean testicular radiation dose was 28.76 µSv while maximum testicular dose was 88 µSv and minimum testicular dose was 5 µSv.

The surface radiation dose during KUB studies ranged from 5 µSv to 88 µSv which is less than the dose required to cause significant health hazard. However, since repeated exposures can have additive effects, the dose should be minimized as much as possible. The radiation dose shows a positive correlation with the BMI, weight, body thickness mAs and kV. However the relationship appears stronger with kV than other variables. Therefore practice of low kV when possible and use of a gonad shield would be reasonable measures to minimize testicular radiation dose further

Keywords— KUB radiography, Ionizing radiation, Radiation dose

I. INTRODUCTION

Discovery of X rays by Wilhelm Conrad Roentgen in 1895 made a significant impact in the field of medicine. After the discovery of X-rays, their implementation in medical practice, for diagnosis purposes have become one of the most rapid and remarkable technological interventions (Hall, 2002). Even though X- rays play a precise role in the diagnosis of diseases by means of imaging, any living tissue in the human body can be damaged by ionizing radiation. The body attempts to repair the damage, but sometimes the damage cannot be repaired or it is too severe to be repaired. Also mistakes made in the natural repair process can lead to cancerous cells (Little, 2003).

A. Biological Effect With Ionizing Radiation

Ionizing radiation contains energy adequate to break chemical bonds and separate electrons from the parent atoms and molecules, leading to the formation of ions in the irradiated material

When X-rays pass through the human body, they can cause changes in cells in atomic or subatomic levels. Most such cells are effectively repaired by the body defense mechanisms. If these damaged cells are not adequately repaired they either die or survive as mutated cells. These mutated cells have a potential to become cancerous if it is a somatic cell, or lead to inherited disease if it is a germ cell (Little, 2003).

B. *Effect Of Ionizing Radiation On The Male Reproductive System*

Testes or the male gonads are highly radiosensitive organs. Therefore, they are more prone to biological damage following exposure to ionizing radiation. Direct radiation dose as low as 0.15 Gy (150 mGy) is known to cause a significant depression in the sperm count and a slightly higher dose than 0.3 Gy causes a temporary azoospermia (Ogilvy-Stuart & Shalet , 1993).

When medical exposure is considered, irradiation of testes may occur during the therapeutic procedures as well as the diagnostic procedures by means of either direct radiation or scattered radiation. Testes may receive scattered radiation from radiological procedures such as KUB (Kidney, Ureter, Bladder) radiography, abdominal and pelvic radiography and computed Tomography (CT) scans of the abdomen and pelvis (Ogilvy-Stuart & Shalet , 1993).

C. *KUB X-Ray Examination*

The supine radiograph of the abdomen is one of the most common investigations carried out to diagnose abnormalities of the kidney, ureter and bladder in the routine clinical set up. It has several advantages to its own merit which cannot be replaced by any other method. It is a quick study and can be interpreted by many. It is one of the most reliable methods to identify calculi in the urinary tract. Urinary bladder, two kidneys and the lateral border of the psoas muscle should be included in the standard routine KUB radiograph.KUB examination is done with patient supine and X-Ray beam is directed anteroposteriorly collimating the beam to include the kidneys up to the symphysis pubis (Whitley *et al* .,2005).

D. *Patient Radiation Protection With Medical Exposure*

Radiation administration is governed by three principles: the ethical justification of an examination, the choice of equipment and procedural optimization and the ALARA (as low as reasonably achievable) principle.

ALARA principle is the best concept which describes radiation protection in relation to medical exposure. Accordingly any protection measures which are easy to use, do not impair image quality, and significantly reduce X-Ray exposure should be used with any medical exposure.

Lead shielding of gonads is the routine dose reduction method to the male gonads during X-Ray exposure in CT. With a 1mm lead shield, the mean testicular dose was reduced from 2.40 to 0.32 mSv, a reduction of 87% during abdominopelvic Multi Detector Computed Tomography (MDCT) (Hohl *et al.*, 2004).

E. *Radiation Dose and Quantities*

The scientists have adopted special units to describe the amount and nature of ionizing radiation. The term 'dose' is commonly used when ionizing radiation is considered. X-Rays carry much more energy and deposit a part of energy within a body as it passes through. Amount of X-Ray energy absorbed by the tissue, organ or whole body is called as radiation dose (Little, 2003).

1) Equivalent dose (H): The equivalent dose H is the absorbed dose multiplied by a dimensionless radiation weighting factor (W_R) which expresses the biological effectiveness of a given type of radiation (EC, 2004*).* Since W_R for X-Ray is equal to 1, the absorbed dose and the equivalent dose are numerically equal (Bushberg *et al.,*1997*).*The SI units for equivalent dose and absorbed dose are sievert (Sv) and gray (Gy) respectively.

II. MATERIALS AND METHODS

A. *Study Design*

This is a descriptive study which was carried out to estimate the testicular radiation dose during routine KUB examinations.The study was performed at Teaching Hospital Kurunegala (KTH) for a period of four months. Study population included adult male patients above 12 years undergoing KUB X-Ray examination at the hospital. Due to practical issues, patients attending the one of the radiography rooms at radiology department were considered for the study. An Electronic Pocket Dosimeter (EPD) was used to measure the individual testicular radiation dose and a pre-coded questionnaire was used to record patient demographic data and exposure parameters.

B. *Study Sample*

Study sample consisted of 75 male patients above 12 years who underwent routine KUB X –Rays in one of the X ray rooms(C room) in KTH.

C. Equipment

An EPD *model no. PDM-117* (MYDOSE mini) with a digital display manufactured by, *Hitachi Aloka medical Ltd, Tokyo, Japan* was used to measure testicular radiation dose. The minimal unit displayed in this dosimeter was 1 µSv. This Pocket Dosimeter had the capacity to measure the maximum level of radiation upto 9999 µSv (Hitachi-Aloka, 2012). X Ray machine used was KXO-80G model from Toshiba medical system

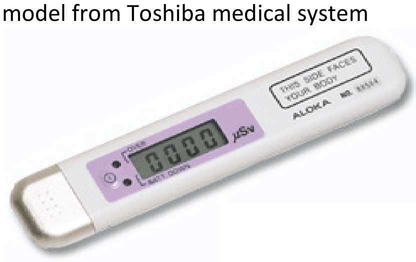

Figure 1. PDM-117 Electronic Pocket Dosimeter (EPD)

D. Methodology

Informed written consent was obtained from each patient before the examination. Each patient was positioned for KUB X –Ray. 30 cm × 40 cm cassette was used. The primary beam was collimated to include the desired anatomy and centered to the midline of the cassette. Exposure factors (kV, mA, s) were manually selected considering the patient's abdominal thickness. All examinations were performed under the large focal spot. EPD was placed transversely over the two testes in such a way that the detector location lying over the midlevel of the testes (approximately 5cm distal to the lower margin of the collimated primary beam). A single layer of thin clothing is allowed between the EPD and the testes to avoid any embarrassment to the patient. End of the each examination, EPD readings were recorded. Since the testicles are superficially located organs and only a minimum of clothing was allowed between the dosimeter and the scrotum, practically it was considered that the equivalent dose to the testis is equal to the dosimeter reading. Correlations were evaluated using Perason correlation test.

Figure 2: Dosimeter positioning on the patient's body

Patient's demographic data was recorded and the weight (BR 2016 ,Camry mechanical personal scale) and height were measured. The average body thickness was measured at the umbilicus level in the midline after positing the patient for the KUB X- Ray. The size of the field of view (FOV) was measured. A brief history of previous radiation studies were recorded from each patient. In this study, the mean testicular radiation dose during the KUB X-Ray was calculated and it was evaluated with different variables to find out whether there is any correlation. The variables were age, weight, body mass Index (BMI), body thickness, kV, mAs, FOV. Correlations were evaluated using Perason correlation test.

III. RESULTS

A. Frequency of KUB X-Rays on a Single Patient

Some patients undergo multiple KUB X-Rays during the same day such as intravenous pyelogram (IVP). The total KUB X-Rays performed during the study period was 918. 75 patients were selected to the study who fulfilled the inclusion criteria. In the studied sample 5% had undergone more than a single KUB radiograph on the same day. There were subjects who have undergone KUB studies or other radiation studies in the abdomen during the last year (Figure 3).

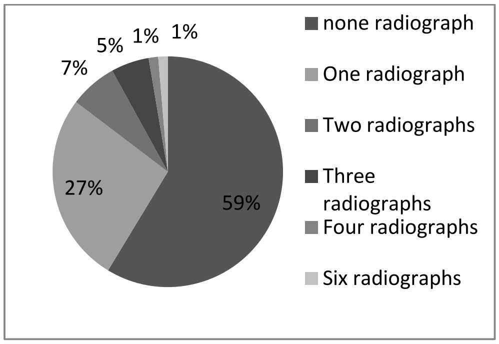

Figure 3. KUB or other abdominal studies during the last year

27% of sample had one previous study while 13% had more than one study in the previous year.

B. Testicular Radiation Dose

Table 1: Summary statistics for testicular radiation dose

Minimum	Q1	Median	Mean	Q3	Maximum	St.dev.
5.00	16.00	25.00	28.76	35.00	88.00	17.524

Individual patient testicular radiation dose varies from 5 µSv to 88 µSv while the mean value is 28.76 µSv.

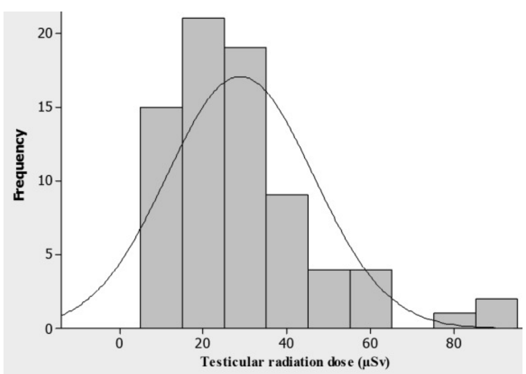

Figure 4. Histogram for testicular radiation

The above graph shows that the testicular radiation dose is positively skewed. The maximum frequency is shown in the range of 15 µSv to 25 µSv.

C. Relationship of Testicular Radiation Dose with Other Variables

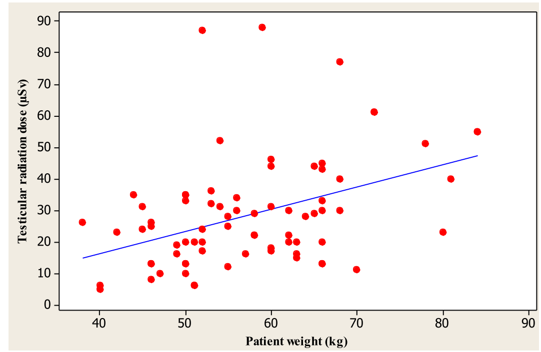

Figure 5. Patients' weight and testicular radiation dose

The above graph shows weak positive correlation between patient weight and testicular radiation dose with a correlation coefficient of 0.252 and a P value of < 0.05

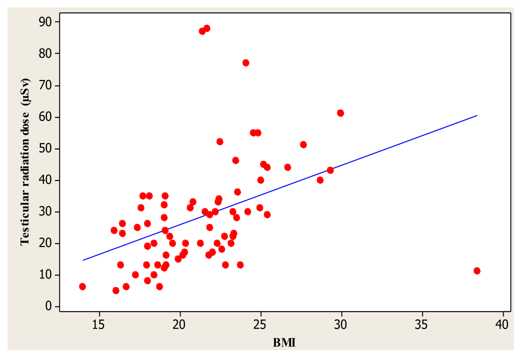

Figure 6. BMI and testicular radiation dose

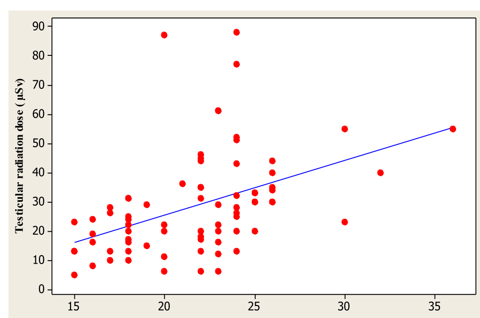

Figure 7. Thickness and testicular radiation dose

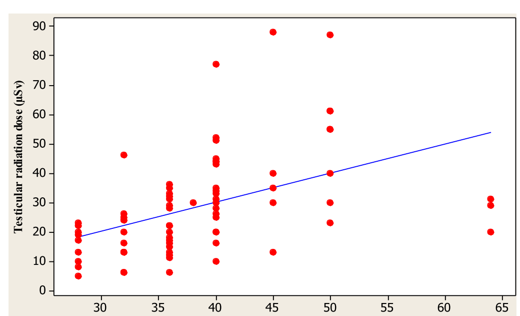

Figure 8. mAs and testicular radiation dose

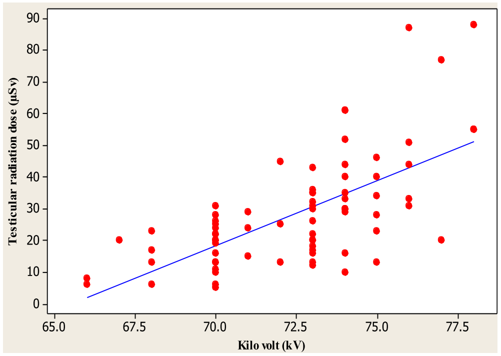

Figure 9. kV and testicular radiation dose

Figure 6 and 7 show weak positive correlations between BMI and patient thickness vs. testicular radiation dose with a correlation coefficient of 0.430 and 0.438 respectively with a P value < 0.05. Testicular radiation dose has also shown moderate positive correlation with kV and week positive correlation with mAs (Figure 8 and 9).The correlation coefficient for the above variables are 0.653 and 0.459 respectively with a P value of <0.05

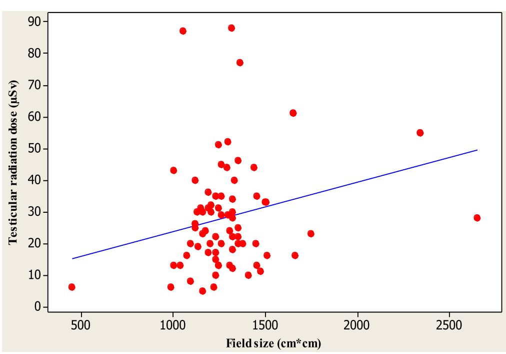

Figure 10. Patients' weight and testicular radiation dose

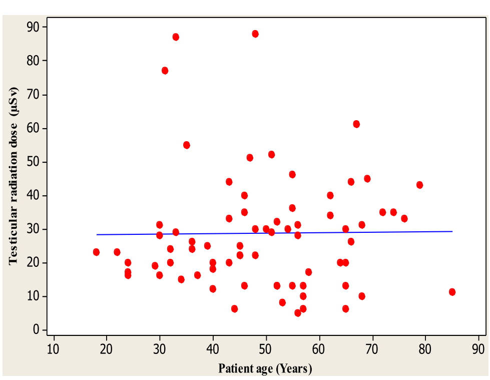

Figure 11. patient age and testicular radiation dose

It has also shown positive moderate correlations between kV and mAs Vs. patient thickness. But no correlation is found with the age of the patients.

IV. DISCUSSION

Ionizing radiations such as X- Rays are widely used in diagnostic imaging in the field of medicine. Although these implementations are medically justifiable, there are inherent hazards for patients, public and health workers. The severity of these hazards depend on the type and the intensity of radiation involved and the part of the body exposed while some risk is generally acceptable. So there should be special concern over radiological examinations or procedures where radiosensitive organs are more prone to be exposed to direct X-Ray beam or indirectly to the scatter radiation such as gonads and thyroid gland.

Testicles or the male gonads are superficially located organs and thus are at a high risk of exposure during radiological investigations of the abdomen. X-Ray KUB examinations are widely performed in the day to day practice and that can lead to a significant exposure to testicles. This survey was carried out to estimate the testicular radiation dose during KUB radiography to identify whether any groups at risk due to higher exposure.

According to the results mean testicular radiation dose during KUB examination was 28.76 µSv while maximum testicular dose was 88 µSv and minimum testicular dose was 5 µSv. Direct radiation dose as low as 0.15 Gy causes to make a significant depression in sperm count (Ogilvy-Stuart & Shalet , 1993). 0.15 Gy absorbed dose is equal to 0.15 Sv of equivalent dose as the radiation weighting factor for X -Ray is equal to 1. So it ensures that there is no significant influence of testicular radiation dose with depression in sperm count as the value is far below than the risk value. Radiation dose as low as 0.3 Gy causes a temporary azoospermia (Ogilvy-Stuart & Shalet , 1993). So it also ensures that there is no significant influence of testicular radiation dose with temporary azoospermia.

In this study seven variables were selected to compare the patient testicular radiation dose with KUB examinations. Patient age, weight, BMI, patient thickness, kV, mAs and FOV were the variables. The results of this study has shown that the patient age around fifty years are more prone to undergo KUB examinations (Figure 11). However there was no significant difference in the radiation dose between the higher age groups and lower age groups in KUB examinations since the surface radiation was measured, the differences in the tissue composition is not accounted.

According to the statistical analysis a positive moderate correlation was found between kV and testicular radiation dose while other variables showed week positive correlation.

kV and mAs values should be increased with the increasing patient thickness to achieve good quality image. But only kV has shown a stronger relationship with testicular radiation dose compared to mAs.

V. CONCLUSION

The testicular radiation dose during KUB X - Ray examinations have ranged from 5 µSv to 88 µSv which is very much less than the dose required to cause significant health hazard permanently or temporarily.

However, since repeated exposures can have additive effects, the dose should be minimized as much as possible.

The testicular radiation dose has shown positive correlations with the BMI, weight, body thickness mAs and kV but no correlation was shown with the patients' age. However the relationship appears stronger with kV than other variables.
Therefore practice of low kV and high mAs with the increasing patient thickness is always desirable whenever it is possible and the use of a gonad shield during high kV exposures would be reasonable measures to minimize testicular radiation dose further.

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