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Measurement of testis absorbed dose in some common medical x-ray examinations using a Rando phantom

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Abstract: *The anatomical position and radiosensitivity of the testis makes it an organ of critical concern in medical radiography, especially in investigations of the pelvis, lumbosacral vertebrae and abdomen regions. This article presents results of testis absorbed dose measured for 12 common general x-ray examinations. Imaging was performed on a Rando phantom using x-ray machine with doses measured using the particular LiF: Mg, Ti thermoluminescence dosimeters (TLD 100). The average measured values for the 12 x-ray examinations ranged from 0.09±0.03mGv for posterior-anterior (PA) chest radiography to 1.89±0.01mGv for anterior-posterior (AP) radiography of the abdomen.*

Key words: *testis, absorbed dose, radio-sensitivity, thermoluminescence.*

I. Introduction

The increasing use of diagnostic x-ray procedures has made the dosimetric evaluation and optimization of such procedures an important consideration in clinical practice, with ongoing efforts to minimize patient dose without compromising diagnostic information content(IAEA, 1996; ICRP, 1990). Importantly, one third to one-half of medical decisions is based on X-ray diagnosis, and early diagnosis of some diseases relies almost exclusively on X-ray examination (Chougule, 2005). World-wide, there are about 1.7 million radiography units and 40,000 CT scanners, and about 2.4 billion X-ray-based examinations are performed annually(Chougule, 2005) Patient doses in radiography depend primarily upon the entrance surface dose (ESD) and the sensitivity of the organs and tissues that are irradiated during the radiographic examination(Faulkner, Jones, Walker, & Hendee, 1996).

For assessment of effective doses (EDs), estimates of organ absorbed doses are required. For at least some organs such as the thyroid and testes, estimation of patient absorbed doses can be based on TLD measurements placed on the overlying skin. However, because of the very small absorbed doses associated with most radiographic procedures, extremely sensitive dosimeters are required. The minimum detectable dose for TLD-100 dosimeters has been reported to be 50-100 µGy(Burke & Sutton, 1997). In this study, measurements have been made of the critical organ dose (testis absorbed dose) associated with 12 common medical radiography procedures, including chest x-ray (PA and Lateral), cervical x-ray (AP and Lateral), skull x-ray (PA and Lateral), thoracic x-ray (AP and Lateral), lumbar x-ray (AP and Lateral), abdomen x-ray (AP) and pelvis x-ray (AP). AP signifies an Anterior to Posterior projection while PA signifies the obverse projection.

II. Materials and method

Optimization of radiological protection points to keeping doses as low as reasonably achievable, economic and societal factors being taken into account. In clinical radiography this is best described as management of the radiation dose to the patient, commensurate with the medical purpose (ICRP, 2008). In present study, use has been made of a three-phase Bennett HEQ-6000 x-ray machine, located in the Secondary Standards Dosimetry Laboratory (SSDL) of the Malaysian Institute for Nuclear Technology Research (MINT). The machine, made in USA and produced in 1970, operates in the 200 mA range.

Rando phantom

All measurements of testis absorbed dose were performed on the Rando Alderson phantom. The particular Rando phantom used in the current study was an adult head and torso phantom comprised of thirty-five 2.5-cm thick transverse sections (Figure 1).

Figure 1 The Rando man phantom used in present investigations Phantom dosimetry procedures

Testis absorbed doses were measured with reference to the following parameters:

- Radiographic procedures and projections (PA, AP and Lateral)
- Source to image receptor distance (SID)
- Radiation technique factors [kilo Voltage Peak (kVp) and mili Ampere second(mAs)]

Other parameters affecting the radiation doses included the type and speed of the radiographic film used as the imaging receptor green sensitive film with speed 400 – Fuji medical x-ray film, Tokyo Japan, also the type of intensifying screens was Lanex regular, Gd_2O_2S:Ti, manufactured by Kodak with speed class 400, and The type of couch was carbon fiber type. Dose measurements were performed using LiF: Mg, Ti (TLD-100) thermoluminescent chips of dimension 0.85 mm thick and 3 mm diameter. For all of the 12 radiographic procedures, small radiolucent sachets, each containing two TLD chips, were taped onto the phantom surface, at the position of the testis. Recorded doses are the values of evaluated dose for all radiographic projections. The TLDs were calibrated in the SSDL, and were read out with a Harshaw 3500 TLD reader.

Exposure factors

The radiographic technique factors used in this experiment, including mAs, kVp and SID are summarized in Table 1.

Table 1 Radiation technique factors used in current study and testis absorbed dose values

Radiographic Projection	kV_p	mAs	SID (cm)	Testis absorbed dose (mSv)
Chest (PA)	80	6	180	0.09±0.03
Chest (Lat)	80	25	180	0.11±0.03
Skull (PA)	65	32	100	0.13±0.04
Skull (Lat)	57	24	100	0.15±0.05
Cervical (AP)	60	22	100	0.20±0.02
Cervical (Lat)	57	22	100	0.17±0.02
Thoracic (AP)	65	38	100	0.18±0.02
Thoracic (Lat)	80	28	100	0.20±0.04
Lumbar (AP)	53	60	100	1.37±0.03
Lumbar (Lat)	80	65	100	0.40±0.04
Abdomen (AP)	70	46	100	1.89±0.01
Pelvis (AP)	60	50	100	1.23±0.03

III. Results

It is first to be acknowledged that many dosimetric experiments have been carried out using Rando phantoms, measured for optimal clinical radiographs based on established evaluation criteria which have taken from Merril,s atlas of radiographic positions & radiologic procedures book (10th edition), and clark,s positioning radiography book(12th edition). The qualities of radiographs were assessed by one medical physicist and one radiology technologist. The results obtained are shown in table 1 and evaluation criteria, which is controlled. The summarized results are shown in table 1 and figure 2.

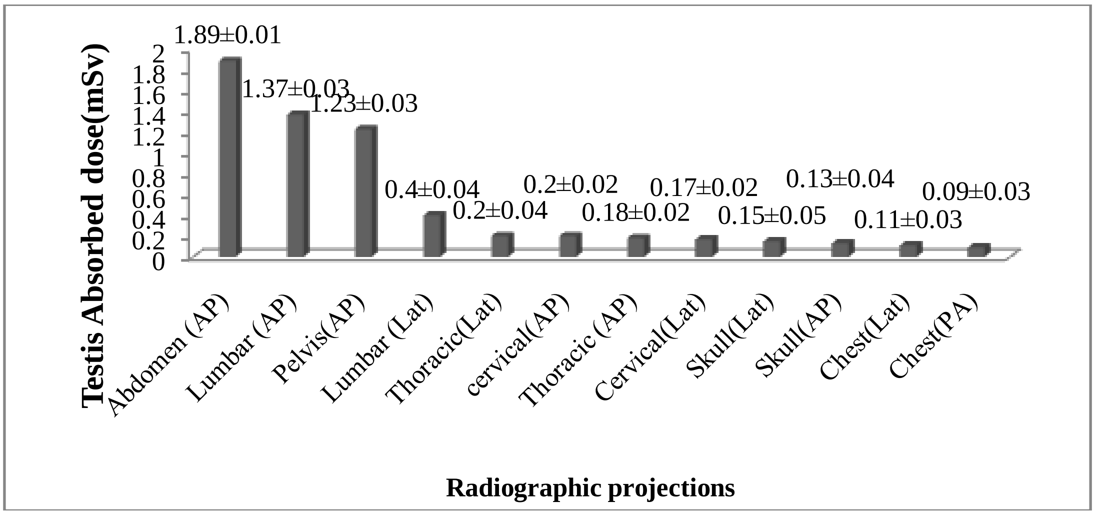

Figure 2 Testis absorbed dose(mSv) in 12 common medical X-ray examinations

As shown in Figure 2 the highest testis absorbed dose value is observed for the abdomen AP projection, at (1.89±0.01) mSv, while the lowest is from the chest PA projection, at (0.09 ± 0.03) mSv.

IV. Discussion and conclusion

The results obtained in this study show that scattered radiation can contribute significantly to the dose to the testis. For example, in AP radiography of the skull, despite the separation between the radiographic field and the testis gland, the absorbed dose to the testis has been found to be 0.15 ± 0.05 mGv. Based on the principle of ALARA, shielding could be used to reduce the absorbed dose to this critical organ to avoid genetically effects.

The choice of radiation technique factors plays a well understood crucial role in testis absorbed dose. For example, in PA chest x-radiography, despite of the wide radiation field, the absorbed dose to the testis is the lowest of all the radiographic procedures investigated in the current study, due to the high kVp and low mAs used for this procedure. The position of the testis relative to the X-ray beam affects its absorbed dose as well, so that, despite the high mAs and kVp used for lateral radiographs of the lumbosacral vertebrae compared to those used for AP radiographs, the testis dose for the latter is less than that for former due to the upper femoral region overlying the testis in the lateral projection.

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