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Patient Dose Measurements in Interventional Radiology

S. Mehdizadeh[1], M. A. Owrangi*[2] and Sh. Derakhshan[3]

1. Radiation Research Center, Shiraz University, Shiraz, Iran
2. Department of Nuclear Engineering, Shiraz University, Shiraz, Iran
3. Radiation Research Center, Shiraz University, Shiraz, Iran

Abstract : The use of X-ray in cardiac interventional radiology has the potential to induce deterministic radiation effects on the patient's body and organs. An investigation was performed to determine the distribution of radiation dose received by the patients during the interventional radiology procedure. Measurements of the radiation dose to the patients were conducted using thermoluminescent dosimeters for individual interventional radiology cases. Measurements were made on thyroid, gonads and both anterior and posterior aspect of the heart. Results suggested a non-uniformity of dose with the maximum dose being measured on the posterior aspect of the heart which shows the Entrance Skin Dose (ESD). Results from these examinations using identical equipments show that the minimum dose is absorbed by the gonads which indicate that the absorbed dose varied inversely with the distances form the entrance dose area.

Key words : Patient dose, Exposure, Radiation, X-ray

Introduction :

The collective effective dose to a population, among man made sources of radiation, is due to a large number of medical X-ray examinations performed (Hughes and O'riordan, 1993). This investigation is different from simple diagnostic investigations as they involve a shift in technique and procedures. Wide differences exist between radiographic and fluoroscopic parameters among radiologists performing these procedures (Rowley *et al.*, 1987). Many attempts have been made in the past to measure the patient dose during special procedures using dose area product and Mont Carlo techniques (Drxler *et al*., 1985; Jones and Wall, 1985; Rosentien, 1998; Shrimpton *et al*., 1984; Calzado *et al*., 1991). The impact of digital imaging on patient dose was studied (Broadhead *et al.*, 1995; Waren Forward *et al.*, 1998).

The equipment used for special procedures in our country is mainly image intensifiers which display and record data analogously. These have strict exposure requirements and because of their narrow latitude offer very little possibility of image processing. More over no clear dosage patterns are available from our country as very little attempts have been made in measuring dose values in these procedures. The purpose of this study is to determine patient dose during interventional fluoroscopic procedures. The corresponding data was acquired from eighteen patients conducting procedures in the same fluoroscopic suits. Eight cases examined for this study were children and the rest were adults. The data were analyzed to determine the average patient dose and to determine if there was a correlation between patient dose and fluoroscopy time used for each procedure. In this study, measurements were made with TLDs on gonads, thyroid, posterior and anterior aspect of the heart during each of the eighteen cases.

Materials and Methods :

This study was performed to analyze the dose to the trunk anatomy of the patients. This study analyzed gonads, thyroid, anterior

* **Corresponding author :** M. A. Owrangi, Department of Nuclear Engineering, Shiraz University, Shiraz, Iran. E-mail : maowrangi@yahoo.com

and posterior aspect of the heart. TLDs were placed in small, sealed packets for protection and then taped to patient's marked places. Patients for each case of this study ranged from a 1.2 years old child to 70 years old man with weights ranged from 11 Kg to 85 Kg. This mixture represented a range of different sizes and diseases and allowed for the variation of the procedure techniques among them.

This study involved measurements during eighteen patient procedures. Eight of them were children with ages ranging from 1.2 years to 4 years and ten of them were adults ranging from 40 to 70 years in age. All the catheterizations were done from right femoral artery or vein. Fluoroscopy times ranged from 1.4 min to 13 min with an average of 6.15 min for children and 3.14 min for adults.

The TLDs used for this study were TLD-100, a lithium fluoride (LiF) formulation with a magnesium impurity, manufactured by (Bircon/Harshaw). Two TLD chips were paired at each measured location on the patient, and each data was cross checked for reproducibility. After each study the packets were opened and the TLDs were read. Background TLD measurements were subtracted from the patient dose TLD measurement. The patient weight, X-ray technique and fluoroscopy time were recorded for each examination.

Patient Dosimetry :

Dose measurements were anatomically oriented to suit a particular investigation. Both anterior and posterior points were selected. Different calibration factors were assigned for posterior points. The mid line of the patient at the level of umbilicus was used as reference points for ovary dose measurements. The sinus process in the third vertebra was selected as a representative point for measurements of the entrance exposure. The thyroid and testes doses were assessed by directly keeping TLDs in the organ sites. The radiographic factors such as KVp, mAs, screening time, screening mA and screening KVp were noted in each patient. Ten TLDs were used per investigation.

The estimation of organ doses during special procedure involving screening is complex. The variation of beam size and areas vary from patient to patient. Additional TLDs were used in situations when it is needed. Organ doses were estimated from the patient skin doses with correction factors for X-ray spectral variations and inverse square variations (Rosentien, 1998).

Results :

The average radiation doses received during an interventional radiology procedure by children are shown in Table 1. The results suggest that thyroid received dose, approximately five times more than gonads and that is because the distance between the heart and gonad is more than the distance between heart and thyroid.

Table 2 Lists the average radiation dose received by adults. The dose values show a maximum average dose for cardiac region. In both studies the gonad doses were the lowest compared to the cardiac region and the thyroid.

Figure 1. and Figure 2. Show some fluctuations in doses to the thyroid and the cardiac region due to the complexity of each interventional radiology. It is noted that children received more dose than adults. This is due to the difficulties of the children catheterization procedures compared to those of the adults.

Discussion :

The measurement of organ doses with the same sufficient accuracy as in the computations is a difficult job. The uncertainties in the dose-meters and variations in the exposure factors contribute very much to this effect. The largest organ dose is measured when the organ is in the field of view *i.e.* in the primary beam. In these conditions, the organ dose computed will be accurate. When the organ is outside the primary, the

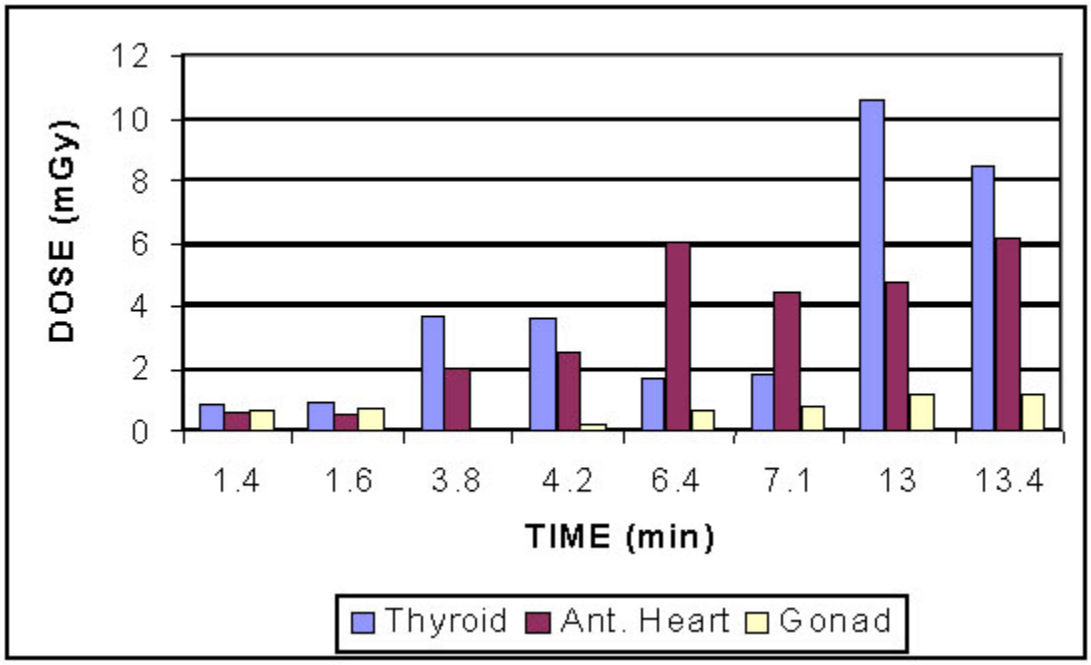

Fig. 1 : Children Dose Measurement : Each dose measurement is the average of more than 10 experiments on different patients should be omitted.

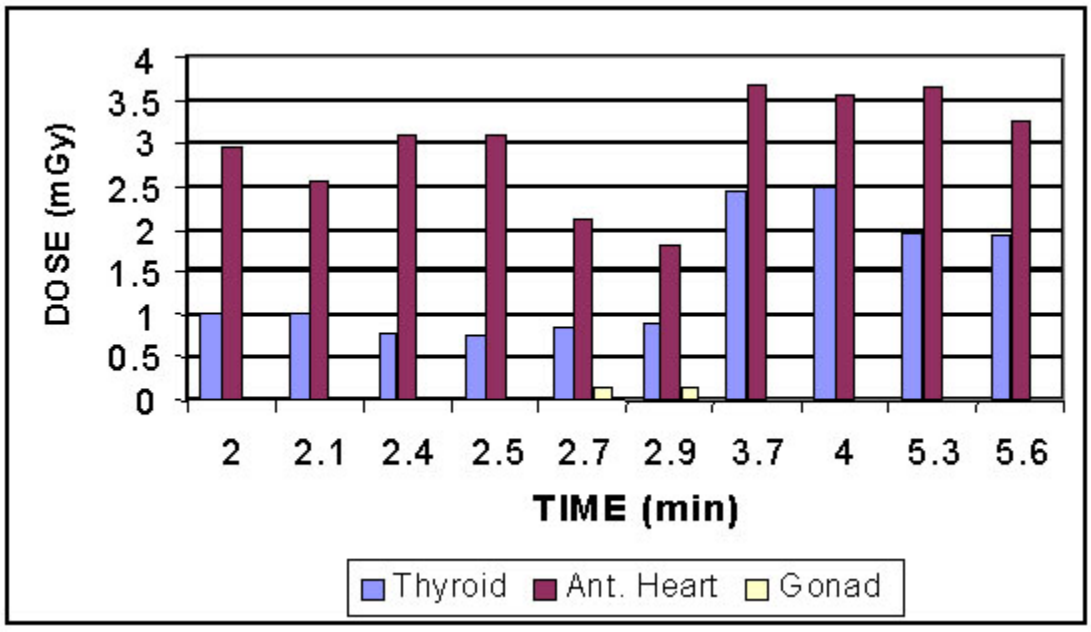

Fig. 2 : Adults Dose Measurement : Each dose measurement is the average of more than 10 experiments on different patients should be omitted.

Table 1 : Radiation dose to children from interventional radiology

	Thyroid (mGy)	**Ant. Heart** (mGy)	**Gonad** (mGy)
Average	4.60	3.38	.70
S. D.	3.64	2.26	.38
Min.	.87	.54	.12
Max.	10.55	6.14	1.16

Table 2 : Radiation dose to adults from interventional radiology

	Thyroid (mGy)	**Ant. Heart** (mGy)	**Gonad** (mGy)
Average	1.41	2.97	.15
S. D.	.71	.65	.01
Min.	.76	1.79	.14
Max.	2.50	3.69	.16

question of accuracy will be doubtful. This is because of uncertainties in the low dose measurements. Because of the sensitivity of LiF dosimeters for low doses the results are more reliable. The difficulties when the organ doses are computed for special procedure lies in the orientation of the beam.

The measured values of the skin doses were significant in these investigations. The dose values should be viewed in the light of exposure factors used by experienced radiologists. The gonad dose values obtained by our study were not significant in the case of angiography but the thyroid doses were significant and comparable with cardiac region investigations. The dose comparisons were difficult as the skin doses and organ doses vary, much depending on the techniques practiced by different radiologists. The individual screening mA, screening time and time of fluoroscopy vary from patient to patient and the correlation becomes difficult.

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