ORIGINAL ARTICLE

Do dose area product meter measurements reflect radiation doses absorbed by health care workers?

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Abstract

This study determined the correlation between radiation doses absorbed by health care workers and dose area product meter (DAP) measurements at Universitas Hospital, Bloemfontein. The DAP is an instrument which accurately measures the radiation emitted from the source. The study included the interventional radiologists, radiographers and nurses associated with radiological intervention procedures during the period 1 August 2003 - 31 August 2003. The amount of radiation produced during every procedure was measured by a dose area product meter (DAP) and routinely recorded. The absorbed doses received by health care workers were measured using a thermoluminescent dose meter (TLD). The TLDs were analysed and recorded at the end of each week. Health care workers wore TLDs on the following areas: forehead, thyroid (attached under thyroid guard), and abdomen (worn under lead jacket). A strong positive correlation ($r = 0.9$, $p = 0.0374$) was found between the radiographers' head TLD and DAP meter readings. All other correlations between TLD and DAP readings were not statistically significant. Strong positive correlations were found between the TLD readings of the radiologists' and nurses' bodies, the nurses' and radiographers' bodies and the radiologists' and the radiographers' bodies, all of which were statistically significant.

Introduction

Interventional radiology is often the preferred treatment procedure, but is associated with a certain amount of radiation to the health care workers performing the procedure.[1] The resulting health care worker concern for the risk of ionising radiation has prompted research into radiological procedures[2] and is of importance to the hospital radiation protection sections.[3]

Fluoroscopic procedures are the main source of radiation because high scatter levels are emitted and the body does not uniformly absorb the doses. The head and limbs receive higher doses because a lead jacket protects the body. The yearly effective dose received by interventional radiologists is approximately equal to the natural background effective dose (average 3m SV), but may be higher.[4] Except for the thyroid, the lead jacket protects all or a portion of the 12 organs and tissue the International Commission on Radiological Protection determined as most sensitive to radiation. The use of a thyroid guard also decreases the effective dose by approximately a factor of 2.[5]

Health care workers may receive primary and secondary radiation. Primary radiation refers to when any body part is placed directly in front of the X-ray and secondary radiation refers to radiation received from ray scatter from the patient or X-ray tube leakage.[6]

Adequate training, procedure optimisation and use and availability of protective measures all contribute to decreasing radiation doses received by health care workers.[3]

Regular monitoring of professional radiation is necessary. Thermoluminescent dosimetry is used to measure radiation and the apparatus is placed on various parts of the body, namely under the lead jacket to determine radiation on the entire body, on the shoulder or thyroid guard, and on the hand.[7]

Radiologists receive larger radiation doses during abdominal studies than during cerebral studies, even though the average fluoroscopic time is longer for cerebral angiography. This may be because of the increased diffraction from the patient tissue and the shorter distance between the radiologist and the X-ray tube during abdominal studies. The radiologist's hands receive the highest absorbed dose with an average of 7.1 mRad for cerebral angiography and 39.9 mRad for abdominal and peripheral vascular angiography. The thyroid absorbs the second highest dose.[5]

During cerebral arteriography, health care workers wear lead jackets and the radiation monitor is often placed beneath the jacket. Radiosensitive areas such as the eyes, thyroid and hands are not protected against radiation and are seldom monitored. Tryhus *et al.*[8] found that during cerebral angiograms the radiographer and technician received respectively 3 mREM and 2 mREM radiation doses on areas not covered by the lead jacket. The dosage received is much lower than the maximum radiation dose of 5.0 REM. The patient, however, received much higher doses, with radiation near the eyes measuring 20 REM with the maximum recommended dose being 0.5 REM.[8]

The dose area product (DAP) meter is an instrument mounted on the X-ray tube, which accurately measures the radiation emitted from the source after calibration. This study determined the correlation between radiation doses absorbed by health care workers and DAP measurements at Universitas Hospital, Bloemfontein. If strong correlations exist, health care workers' radiation exposure could be derived from the DAP readings.

Methods

The study included the interventional radiologists, radiographers and nurses associated with radiological intervention procedures that took place from 1 August 2003 to 31 August 2003 at Universitas Hospital, Bloemfontein.

The amount of radiation produced during every procedure was measured by a DAP (PTV Dianometer M2 model) and routinely recorded. The absorbed doses received by health care workers were measured using a thermoluminescent dose (TLD) meter. Health care workers wore TLDs on the following areas: forehead (worn around head with specially designed headband), thyroid (attached under thyroid guard), and abdomen (worn under lead jacket). The respective health care workers' TLDs were colour coded to enable identification. The TLDs were analysed and recorded at the end of every week. Per week, three TLDs were used for calibration and three TLDs measured background radiation in the storage place.

Radiation was measured in cGy and $cGycm^2$ for the TLD and DAP meters, respectively. The TLD and DAP readings that were recorded per week represent all the procedures that took place at the interventional unit during the week.

The following Spearman's rank correlations were calculated: DAP meter readings and TLD meter reading for each health care worker's body area (head, thyroid and body); and TLD head, thyroid and body readings compared between radiologist, nurse and radiographer.

Results

The correlation between the DAP and radiologists' TLD readings are given in Table I and Fig. 1. There was a positive correlation between the DAP and TLD head reading, a negative correlation with TLD thyroid reading, and no correlation with the TLD body reading. No correlation was statistically significant.

The correlation between the DAP and radiographers' TLD readings are given in Table I and Fig. 2. There was a

Table I. Correlation between TLD and DAP readings

Health care worker	Area	Correlation coefficient	*p*-value
Radiologist	Head	0.7	0.1881
	Thyroid	-0.7	0.1881
	Body	-0.2	0.7471
Radiographer	Head	0.9	0.0374
	Thyroid	0.4	0.5046
	Body	-0.2	0.7471
Nurse	Head	0.3	0.6238
	Thyroid	0.2	0.7471
	Body	-0.4	0.5046

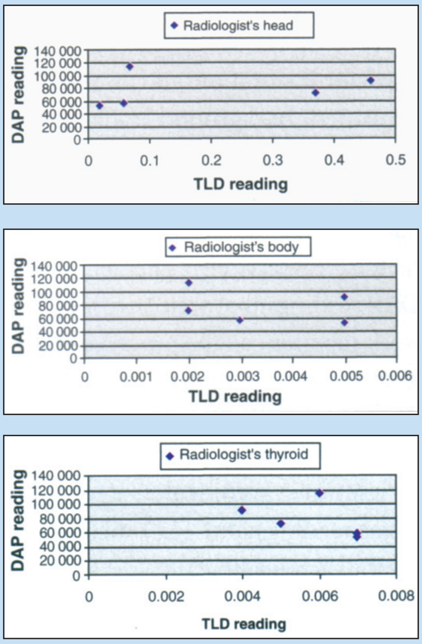

Fig. 1. Correlation between the DAP meter and radiologists' TLD meter readings.

statistically significant positive correlation between the DAP and TLD head reading, no correlation with TLD body reading, and a positive correlation with the TLD thyroid reading.

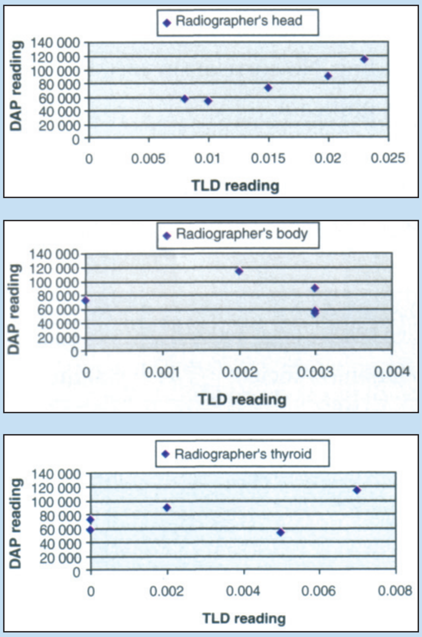

Fig. 2. Correlation between the DAP meter and radiographers' TLD meter readings.

The correlation between the DAP and nurses' TLD readings are given in Table I and Fig. 3. There was a positive correlation between the DAP and TLD head reading, a negative correlation with TLD body reading, and no correlation with the TLD thyroid reading. No correlation was statistically significant.

The correlations between the doses absorbed by the radiologists, radiographers and nurses are given in Table II. Although not statistically significant, a positive correlation was found between the TLD readings of the radiologists' and nurses' heads, as well as between the radiologists' and radiographers' heads. No correlation was found between the TLD readings of the radiographers' and nurses' heads. A negative correlation coefficient was found between the radiologists' and nurses' TLD thyroid readings, but there was a positive correlation between those of the radiographers and nurses, and no correlation between those of the radiologists and radiographers. A strong positive correlation was found between the TLD readings of the radiologists' and nurses' bodies, the nurses' and radiographers' bodies, as well as the radiologists' and the radiographers' bodies, all of which were statistically significant.

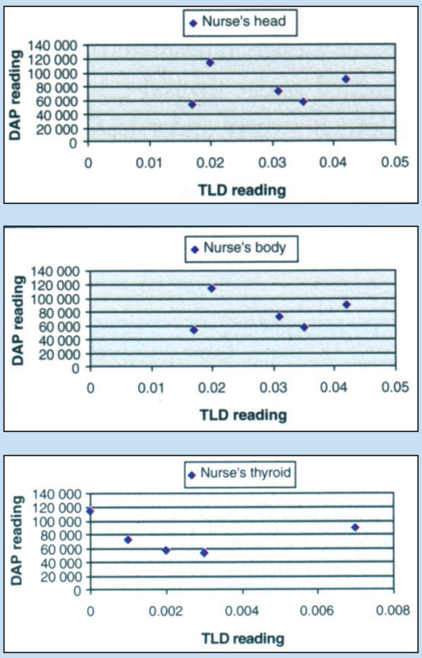

Fig. 3. Correlation between the DAP meter and nurses' TLD meter readings.

Discussion

A positive correlation indicates that an increase in the DAP reading is reflected by an increase in the TLD reading. The radiologist stands nearest to the DAP meter during each procedure and receives a large amount of scattered radiation. The correlation is not statistically significant, possibly because the radiologist's head is moving constantly and each radiologist has a different physical build, which will result in a variable radiation reading. A negative correlation indicates an increased DAP reading, but a decreased TLD reading. The radiologist's body is covered with a lead jacket and by the table, both of which will absorb radiation. The height of the table and the radiologist's physical build also determine whether the TLD is situated under the table. The radiologist may move around during the procedure. These factors would influence the amount of radiation that reaches the TLD.

The significant correlation between the DAP and radiographer's TLD head reading may be because the radiographer's head is not protected and he/she is more static than the nurse or the radiologist. The radiographer sits or stands at the bottom end of the patient, wears lead jackets and is shielded by the table, which may explain the poor correlation between the DAP and radiographer's TLD

Table II. Correlations between the doses absorbed by the radiologists, radiographers and nurses

Area	Comparison	Correlation coefficient	*p*-value
Head	Radiologist with nurse	0.3	0.6238
	Radiologist with radiographer	0.4	0.5046
	Nurse with radiographer	0	1.000
Thyroid	Radiologist with nurse	-0.3	0.6238
	Radiologist with radiographer	0.1	0.8729
	Nurse with radiographer	0.6	0.2848
Body	Radiologist with nurse	0.9	0.0374
	Radiologist with radiographer	1.0	< 0.0001
	Nurse with radiographer	0.9	0.0374

body reading. The sitting position and the radiographer's physical build would also influence the reading. An ineffective thyroid guard, openings on the side of incorrectly fastened guards, and the radiographer's physical build all contribute to variable TLD thyroid readings.

The nurse moves around or sits during procedures. As a result the radiation may have moved through the patient, bed and lead jacket before a reading is registered. The TLD meter receives scattered radiation whereas the DAP meter receives direct radiation escaping from the apparatus.

The TLD body readings of the radiologists, radiographers and nurses showed a strong correlation. The radiation only reaches the TLD meter after passing through other members, the patient, bed, equipment and lead jacket.

Conclusion

The only statistically significant correlation between the DAP and TLD readings was that of the positive correlation between the radiographer's head TLD and DAP meter reading. It is not possible to determine health care worker radiation from the DAP reading because of the general lack of correlation between the DAP and TLD readings.

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