Orthopedist’s Thyroid Radiation Dose During Surgery

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ABSTRACT
Interventional radiology delivers significant radiation dose to the staff. The thyroid gland is a potential target organ for radiation-related damage, as it receives a considerable radiation dose from scattered radiation. This study aimed to evaluate the thyroid surface dose (TSD) to the orthopedist during two types of interventional orthopedic procedures and to estimate the thyroid effective dose and its related risks. Calibrated thermo-luminescent dosimeters (TLDs) were used in 20 procedures which were divided into two groups (A and B) according to the type of the procedure. The TLDs were attached to surgeon's thyroid. A single operation team was performed all the procedures using a C-arm machine. The mean fluoroscopic exposure factor for group A were 71 ± 2.83 kVp, 1.2 ± 0.21 mA and 0.72 ± 0.10 mins, and for group B were 62.6 ± 1.50 kVp, 0.98 ± 0.10 mA and 0.41 ± 0.08 mins. The mean TSD was 71.6 ± 3.06 µGy per procedure for group A and 57.6 ± 2.76 µGy for group B. The TSD during DHS procedure was found to be higher than the TSD during DCS procedure. The adoption of optimization techniques during orthopedic procedures is required in order to reduce the radiation risk to the orthopedist.

Keywords: interventional radiology; thyroid; radiation dose; occupational exposure.

1. Introduction

Radiological risk to the medical staff in interventional radiology is a topic of major concern in medical radiation protection, due to the rapidly increasing use of fluoroscopy (Vano, 1998). Furthermore, the fast development of interventional radiology in recent years has seldom, if ever, been matched by a parallel increase in the number of specialists (Williams, 1997). Thus, workloads supported by interventional radiology staff are often great. In addition, since fluoroscopic image quality can be improved as radiation intensity increases, interventional radiology is prone to overexposure to both the patient and the staff. Various studies (Vano, 1998; Williams, 1997; Ruiz, 1998; Vande, 2000; Whitby, 2003; Devalia, 2006) have been performed to evaluate radiation dose from different types of interventional radiology procedures. The thyroid gland is a potential target organ for radiation-related damage. Thyroid carcinoma is a possible high-dose effect of occupational
exposure to ionizing radiation. This risk can effectively be reduced by wearing appropriate thyroid protection shields (Dewey, 1998). Experimental dosimetry studies demonstrated that these devices decrease the effective organ dose to the thyroid during cardiac catheterization procedures by a factor of 30 or higher (Devalia, 2006).

However, in daily practice during this study, thyroid protection shields are frequently not worn by the medical personnel or are even not provided by the hospital. Thus it seems reasonable to assume that the thyroid is relevantly exposed to ionizing radiation among persons who are generally exposed to occupational radiation dose. The aims of this study were (i) to evaluate thyroid skin dose (TSD) to orthopedist during two types of orthopedic procedures and (ii) to estimate the thyroid effective dose and its related risks.

2. Methodology

2.1 Dose Measurements

TLDs of lithium fluoride (LiF: Mg, Ti: P, GR: 200) chips doped with magnesium and titanium were used (Fimel-France). A total of 60 TLD chips were used in this study. The TLDs were calibrated under reproducible reference conditions using the same X-ray machine (Siremobil 2000) against an ionization chamber model CONNY (Physikalisch-Technische Werkstätten GmbH (PTW)). TLD calibration was performed according to the protocol reported by Sulieman et al 2007.

TLD chips were handled with vacuum tweezers to avoid surface scratching. The TLD signal was read using a TLD reader (Fimel-France). The readout was carried at a 100°C preheat temperature and reading temperature of 100–300°C with heating rate 10°C s-1. Before each irradiation, all dosimeters were annealed in a computerized annealing oven (TLDO; PTW, Freiburg, Germany). The mean background signal for un irradiated TLDs was subtracted before any calculation. The minimum detection limit was determined to be 15 \(\mu\)Gy. The linearity of the TLD’s response for the range of doses used in this study has been verified. The uncertainty of TLD reading was estimated to be less than 10% of all measurements procedures.

2.2 X-ray C-arm machine

A c-arm X-ray machine was used throughout this study, manufactured by Siemens Company in Germany (Siremobil 2000-High frequency generator with maximum tube voltage 120kVp, total filtration of 2.5 mm Al and the machine had capability of last frame hold. The machine was installed in 2009) all procedures were carried in Mulazimeen hospital in Omdurman, Sudan (private hospital). The machine passed successfully quality control tests (kVp and timer accuracy, exposure linearity and reproducibility) performed by Sudan Atomic Energy Commission (SAEC).

2.3 Orthopedist's thyroid entrance skin dose

The patients population were divided into two group according to the type of the procedure performed, Group A Dynamic Hip Screw (DHS, 10 procedures), and Group B
Dynamic Cannulated Screw (DCS, 10 procedures). These two procedures were selected for the study because they are the most commonly performed, and often require numerous images. Three TLDs were enclosed in a transparent polyethylene foil envelope and were placed over the skin at thyroid site as illustrated in Figure 1 and were kept in the required position with cello-tape. Surgeons’ staff wore a rubber lead apron of 0.5 mm lead equivalent as protection from scattered radiation. No thyroid shield worn during all procedures. A single operating team was chosen to perform all the procedures, in order to avoid inter operator variations which could result from the different skills and experiences of the orthopedists.

3. Results and Discussion

The mean fluoroscopic exposure factors for group A were 71 ±2.83 kVp, 1.2 ±0.21 mA and 0.72 ±0.10 mins, and for group B were 62.6 ±1.50 kVp, 0.98 ±0.10 mA and 0.41±0.08 mins. The mean TSD was 71.6 ± 3.06 µGy per procedure for group A and was 57.6 ± 2.76 µGy for group B. Orthopedist were exposed to a higher TSD from DHS procedures than DCS procedures. This might be attributed to the more number of image taken, fluoroscopic exposure time and in turned increased scattered radiation in group A compared to the Group B.

In this study, a comparison was made of the staff radiation doses from other interventional radiological procedures previously published in the literature (Table 1) due to the lack of orthopedics staff dose data in the open literature concerned thyroid radiation dose. The data showed that staff doses in orthopedic procedures are rather low compared to those from more complex IR procedures. In orthopedics procedures, the staff is located at a very short distance to the area of exposure but the beam load and fluoroscopy screening time is low compared to the more complex interventional radiological procedures.

Table 1: Comparison of the average thyroid radiation dose in this study and literature

<table>
<thead>
<tr>
<th>Author</th>
<th>Procedure</th>
<th>Intervventional type</th>
<th>Thyroid radiation dose (mSv)</th>
<th>ESD (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>DHS-DCS</td>
<td>Orthopedic</td>
<td>0.0064</td>
<td>0.064 ± 0.01</td>
</tr>
<tr>
<td>Buls et al (2001)</td>
<td>HSG</td>
<td>Gynecology</td>
<td>0.15</td>
<td>N.A</td>
</tr>
<tr>
<td>Devalia et al (2006)</td>
<td>IM</td>
<td>Orthopedic</td>
<td>0.055</td>
<td>N.A</td>
</tr>
<tr>
<td>Janssen et al (1992)</td>
<td>N.A</td>
<td>Cardiology</td>
<td>0.34</td>
<td>N.A</td>
</tr>
<tr>
<td>Ima et al (2000)</td>
<td>N.A</td>
<td>Cardiology</td>
<td>0.10</td>
<td>N.A</td>
</tr>
<tr>
<td>Sulieman et al (2011)</td>
<td>ERCP</td>
<td>Pancreaticobiliary</td>
<td>N.A</td>
<td>0.23</td>
</tr>
<tr>
<td>Sulieman et al (2008)</td>
<td>HSG</td>
<td>Gynecology</td>
<td>0.0006</td>
<td>N.A</td>
</tr>
</tbody>
</table>

N.A=not available

Table 1, showed a significant variation among interventionalist performed different procedures. The highest thyroid radiation dose associated with interventional cardiology procedures due to the complex nature of these procedures. The orthopedist performed intramedullary nailing IM received the lowest radiation dose to thyroid, compared to the
present study the radiation dose to thyroid was slightly lower and this may attributed to the different procedure encountered during both studies.

In (1996), a preliminary survey of the membership of the Australian Orthopaedic Association (AOA) suggested an increased incidence of thyroid carcinoma in orthopaedic surgeons, due to the used of fluoroscopic image (Dewey, 1996). This perception is the subject of ongoing investigation. Dewey and Incoll (1998) stated in their study for evaluation of the thyroid shields that the perceived increase in the incidence of thyroid carcinoma in orthopaedic surgeons prompted an assessment of the use and value of thyroid shields in the operating theatre. In the aforementioned study, the authors used TLDs chips to monitor the orthopaedic registrar's thyroid. In addition, thyroid function, thyroid-stimulating hormone (TSH), free Thyroxin (T₄), free Triiodothyronine (T₃), antimicrosomal antibody, and antithyrolobulin antibody tests were performed to exclude any abnormality related to radiation exposure. The radiation exposure measured on the TLD monitor ranged from of 0.01 to 0.4 mSv. They reported that the thyroid function results were within normal limits, however the higher TSH levels occurred in trainees with the longest service. Dewey and Incoll (1998) concluded that the orthopaedic surgeons may be more likely to develop thyroid carcinoma if not protected from the radiation exposure. In this study authors noticed protective thyroid collar was not available in the current hospital, so no one of staff wore it.

### 3.1 Thyroid risks estimation

Exposure to radiation over many years promotes the development of thyroid carcinoma (Fuchus 1998). Eighty five percent of the papillary carcinomas of the thyroid are radiation-induced. There is an evidence that carcinogenic potential is exists from low-dose, low energy radiation (Goldstone, 1993; Kaplan, 1984; Stoker, 1992). An accumulated dose of as little as 65 μSv, over multiple exposures can statistically increase the incidence of thyroid cancer, many years later (Fuchs, 1998; Stoker, 1992).

The risk of developing cancer in a particular organ following orthopedics procedures after irradiation was estimated by multiplying the mean organ equivalent dose with the risk coefficients obtained from the ICRP 1990, while the lifetime mortality risk per procedure resulting from tissue reactions was determined by multiplying the effective dose by the risk factor.

In this study the mean radiation dose for thyroid was estimated to 0.0064 mSv which is equal to 64x10⁻⁷ Sv and the radiation risks estimation for fatal cancer and hereditary effects per procedure was found to be 12.8 x10⁻⁹ , as accounted the risk factor for thyroid organ is 20x10⁻⁴ (Sulieman, 2008). To obtain a reasonable assessment of radiological risk for the staff the irradiation of all the radiosensitive organs of the body should be considered.

As the dose limit recommended for the thyroid is 300 mSv per year. With the average dose of 6.4 μSv (= 0.0064 mSv) it would require 4687.5 procedures to reach that dose. From this results with correct workload, the staff dose within acceptable limits, bearing in mind that wearing thyroid shield, will reduce the radiation dose up to 30 times.
4. Conclusion

Radiation doses for thyroid during interventional radiologic procedures in orthopedics are lower than cardiologic procedures for surgeons. Thyroid collar shield has significant role in radiation dose reduction. DHS procedure increase radiation scattered to personnel in the surgery room more than DCS procedure. Continuous evaluation and monitoring is required to achieve more optimization.

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