Estimation of Radiation Dose Received by Vital Organ in Thyroid Scintigraphy

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ABSTRACT: Nuclear medicine (N.M) staff usually received considerable dose during N.M scanning, therefore the estimation of radiation doses received by the forehead, parotid gland and eye lenses (for the thyroid patients) and for the hands, chest and the forehead for the staff; has been considered as objectives in this study. The study was conducted at Radiation and Isotope Center Khartoum (RICK) A total of 45 patients with thyroid goiter and the staff (3 Technologists) were considered in this study. The average patient’s surface doses for forehead were 0.10 ± 0.02 mGy, salivary gland (parotid) was 0.09 ± 0.04 mGy and thyroid surface dose was 0.10 ± 0.05 mGy per exam. The staff radiation dose for the hands was 0.21 ± 0.03, 0.08 ± 0.04 mGy for the chest, and 0.07± 0.05 mGy for the forehead.

KEYWORDS: Thyroid, Radiation risks, Staff dose, Thermoluminescence dosimeters, Nuclear medicine.

INTRODUCTION

Nuclear medicine staff commonly exposed to a considerable ionization radiation to the whole body consequential from eluting and preparing and administration of the 99mTc/99Mo, as well as from patients during the procedure which imposes radiation risks for both patients and staff (ICRP, 1990; Thea, 2002).

Although the evaluation of the exposure to patients and staff is recommended (ICRP 103), as far as we know from the open literature, this is the first study to be conducted in Sudan caring about the organs exposure in N.M, with limited publications from similar studies elsewhere on the staff.

Within this scope, Pant (2006), reported the doses registered at the base of the fingers for 3 physicians and a weekly absorbed dose of 1.2 mSv/week. The doses in the present study, of the order of 0.2 mSv/week, suggested that exposure was not likely to exceed the annual limit.

Mountford, (1991) measured the dose at distances of 0.1, 0.5 and 1.0 m from 148 paediatric patients who had undergone one of 12 99mTc studies. The maximum dose rates of 70, 14 and 5 μSv/h at these distances were not greater than the corresponding maximum values found in an earlier study of adult patients.

Guillet (2005) measured technologist radiation exposure in routine clinical practice with 18F-FDG PET. Finger irradiation doses during preparation of single 18F-FDG syringes were 204.9 – 24.0 and 198.4 – 23.0 μSv with multidose vials (345 -93 MBq injected) and 127.3 - 76 and 55.9 - 47 μSv with monodose vials (302 - 43 MBq injected) for the right hand and the left hand, respectively.

Thea, (2002) studied the radiation dose to nuclear medicine technologists in nuclear medicine department. The average doses were measured for different types of activities. Performing injections registered a dose rate of approximately 2 μSv/h. Doses received while scanning ranged from 0.2 to 2 μSv/h. The average dose for a scan depends not only on the administered activity and isotope but also on the amount of patient contact required. Tsopeles, (2003), reported that withdrawing activity through a modified lid on the lead pot housing the elution vial, a reduction in
the photon flux to the fingers/hands of up to 84% can be achieved.

Bolus (2008), reviewed a common occupational hazards and safety concerns for nuclear medicine technologists review was intended to concentrate on common hazards and safety concerns.

Taha (2008) measured hand dose that accumulated in 4 weeks in nuclear medicine staff members. The maximum expected annual dose to the extremities appeared to be less than the annual limit (500 mSv/y) because all of these workers are on rotation and do not constantly handle radioactivity throughout the year.

These studies showed wide differences in terms of dose, protocols and choice of radioisotope therefore the estimation of radiation doses received by the forehead, parotid gland and eye lenses (for the thyroid patients) and for the hands, chest and the forehead for the staff; has been considered as objectives in this study.

The study was conducted at Radiation and Isotope Center Khartoum (RICK).

**MATERIALS and METHODS**

**Materials**

**TLDs**

A total of 50 thermoluminescence dosemeter (TLD) circular chips of lithium fluoride (LiF:Mg,Cu,P) were used in this study. Prior to measurements, all TLD were calibrated in terms of air kerma free-in-air under reproducible reference condition using $^{99m}$Tc with activity 10 mCi (370 MBq). Calibration of the detector in the same energy enables us to exclude energy correction factors and reduce possible source of error. TLDs were placed at equal distances from source in a circular holder. Individual calibration factors were obtained by irradiating the entire group to the same dose and the process was repeated three times. The TLD were kept in a low-background-radiation area when not in use and background signal was subtracted from all TLDs. Data concerning the study population were composed of 45 patients with thyroid goiter referred to RICK for thyroid scan.

**Gamma camera**

Scintillation gamma camera (Nucline™ SPIRIT DH-V, Variable Angle Dual-Head Digital Gamma Camera for SPECT, equipped with a parallel hole collimator as illustrated in Figure 1 was used.

![Fig 1: Nucline gamma camera computer system (planer and dual head whole body SPECT) with general purpose collimators](image)
Methods:

Patient dose measurement:
A total of 45 patients with thyroid goiter referred to RICK for thyroid scan were included in this study. The Ethics and research committee at RICK approved the study and a written consent was obtained from each patient prior to the procedure. TLDs were packed on transparent plastic envelopes containing three TLDs. Three envelopes were used to measure patients' radiation dose of forehead, salivary (parotid gland) and thyroid glands as illustrated in Figure 2.

![Figure 2: Monitored sites on the patient during thyroid scan](image)

During the procedure the TLDs were kept in the required positions using adhesive tapes. The data recorded for all procedures included: patient body characteristics (age, gender, height, weight and body mass (BMI) weight/height in kg/m², activities of radioactive material and clinical indication. For the staff, the radiation dose was monitored at 3 sites: the forehead, chest, and left hand as shown in figure 3.

![Figure 3: monitored sites on the technologist during thyroid scan](image)

99mTc thyroid imaging techniques:

The thyroid was imaged 15 minutes after the intravenous administration of 4.5 mCi of 99mTc Pertechnetate. Anterior image were then obtained with the patient supine and neck extended. 600 second exposure per image or 200 k counts/image (Sharp (2005)).

RESULTS

The mean ± standard deviation (SD) of patients age was 38 ±13, mean ± SD weight was 65± 14 and mean ± SD body mass index (BMI) was 26±4 (Table 1). As expected, no significant correlation was found between patient dose and patient characteristics because the dose was fixed.
The radiation dose was comparable for patient organs as illustrated in Fig 4. This may be attributed to the fact that $^{99m}$Tc in contrast to $^{131}$I does not concentrate in the thyroid alone, but is distributed to all adjacent organs. Fig 5 shows the surface doses to the hands, chest and forehead of the staff. As predicted, the radiation dose to the hands of the staff was slightly higher than those for the forehead and chest. As expected, the radiation doses to the hand of the staff involved in intravenous administration were observed to be higher than the other parts.

**Table 1** Mean ± standard deviation (SD) of Patients body characteristics

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age (years)</th>
<th>Height(cm)</th>
<th>Weight (Kg)</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>45</td>
<td>37.47 ±13.235</td>
<td>163.87±10.248</td>
<td>65.22±14.638</td>
<td>25.82±4.4</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Staff in nuclear medicine departments may receive significant radiation doses to their unprotected parts. In this study the surface doses received by the technologist at the forehead, chest and the hand were measured. These organs are at higher risks than other organs since they are closer to the radiation sources in most situations during handling of radioactivity. The average surface dose to the hand of the technologist involved in radiopharmaceutical injections was recorded to be 0.21 ± 0.03 mGy which is far below the maximum permissible dose (20 µSv/year).

Selection of a lower activity and a better patient positioning for the procedure may reduce the radiation dose.

As thyroid scintigraphy involves direct irradiation of the internal and radiosensitive organs of the patient, surface doses for specific organs were estimated as illustrated in Figure 4. The radiation surface dose is comparable for all three organs. This can be easily explained due to the use of $^{99m}$Tc instead of $^{123}$I which concentrate only in thyroid glands conversely to $^{99m}$Tc. Therefore all adjacent organs absorbed the radioactive material. Iodine is not available because it is more expensive than $^{99m}$Tc, which is more available and of multipurpose applications, which made it favorable in Sudan. Pant (2006), reported the doses registered at the base of the fingers for 3
physicians and a weekly absorbed dose of 1.2 µSv/week. The doses in the present study, of the order of 0.2 µSv/week, suggested that exposure was not likely to exceed the annual limit. In this study, either a protective eyeglass or thyroid collar were worn by the staff. The technologists were performing the investigations as their daily practice with a protocol of RICK department and were advised to avoid any possible radioactive contamination. The hands receive a much higher radiation dose than other parts of the body (ICRP 1990, Thea, 2002). The radiation exposure to the hands, however, results not only from the syringe withdrawing 99mTc-pertechnetate activity but from the remaining, higher activity in the elution vial contained in the lead pot. Tsopelas, (2003), reported that withdrawing activity through a modified lid on the lead pot housing the elution vial, a reduction in the photon flux to the fingers/hands of up to 84% can be achieved. The staff could exceed the annual dose limits in this department when heavy duty coexists. Further study is required for dose optimization. It is important to note that, in agreement with our results, Harding 1987, has reported that the major components of doses received by technologists is from the patient, rather than from handling syringes in radiopharmaceutical preparation and injection. On the other hand, another study reported that a measured dose per procedure of 0.2-0.4 µSv was obtained for conventional procedures.

CONCLUSIONS
The results in this study revealed that staff radiation surface doses were considerable. Satisfactory radiation safety standards and good work practice are highly required to improve radiation protection. Selection of the suitable dose of activity and good patient positioning for the procedure could also reduce the radiation dose.

REFERENCES