Radiation dose to the nuclear medicine nurses

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ABSTRACT

**Background:** People who have been administered radiopharmaceuticals could be a source of radiation to their relatives, medical nurses, and people who are in contact with them. The aim of this work was to estimate radiation dose received by nuclear medicine nurses.

**Materials and Methods:** In this study, the dose rates at various distances of 5 – 100 cm from 70 patients, who were administered diagnostic amounts of $^{201}$Tl-Chloride and $^{99m}$Tc-MIBI, were measured using an ionization chamber. For determination of external radiation dose to the nurses, three different time intervals were used for measurements.

**Results:** The maximum values of external dose rates of $^{201}$Tl and $^{99m}$Tc-MIBI were 11.2 µSv/h ±2.3 and 43.1µSv/h ±11.9 respectively, at 5cm from the patients. Significant exposure from patients after injection of $^{99m}$Tc-MIBI was limited to the day of administration. Departure dose rate of $^{201}$Tl fell gradually; so, it became significant by 3 days after administration. Maximum and average absorbed dose of nuclear medicine staff from $^{201}$Tl, was 4.6 and 2.7 µSv/h, and for $^{99m}$Tc-MIBI was 18.1 and 9.8 µSv/h in each scan.

**Conclusion:** Significant exposure from the patients is limited to the few hours after administration, therefore patients should be recommended to urinate frequently before leaving the nuclear medicine department.

**Keywords:** External radiation, absorbed dose, radioactive patients.

INTRODUCTION

Patients who have received radiopharmaceuticals become a source of contamination and exposure for people, who come in contact with them, such as nuclear medicine technologists, nurses, visiting relatives (Shin-yin and Douglas 1992). Thallium Chloride and Technetium-Metoxy isobutil isonitril (MIBI) are the most frequently used radioisotopes in Iran, which have been produced in cyclotron department at Nuclear Research Center for Agriculture and Medicine (NRCAM) (Haji Saeid and Afarideh 1995). Excretion rate, biokinetic models and dose rates per unit activity of this radiopharmaceuticals have been presented in ICRP 1991, but practical excretion and dose rate measurements have been considered only in few papers (Sattari 2001, Mountford 1991, Konishi 1994). The aim of this research has been to study the absorbed radiation dose to nuclear medicine nurses.

MATERIALS AND METHODS

In Rajai Heart Center (Tehran), 70 patients were selected for this study. These patients were divided into two groups: a) Patients who had received $^{201}$Tl-chloride; b) Patients who had received $^{99m}$Tc-MIBI. Table 1 gives data on the patients and their administrated activities. For all subjects, name, age, type of compound and...
other relevant details were recorded. No diuretics and β- blocking agent were given to any patient during this study. Each administrated activity was measured using the radioisotope dose calibrator (Capintec-CRC-30 RC). For determination of external radiation dose, a small ionization chamber (Minera model SM2000x) was used. The chamber was calibrated by a standard source of $^{57}$Co and $^{137}$Cs in the Secondary Standard Dosimeter Laboratory (SSDL) department in NRCAM. Dose rate was measured at distances of 5, 10, 50 and 100 cm from the left side of each patient’s naval, while the patient was laid supine on a hospital bed. The measurements were done at 3 different time intervals: 30 minutes, 3 hours and 5 hours after injection. In order to measure the external dose rate as a function of time, the measurements were repeated 24 and 48 hours after injection.

For determination of external radiation to the nurses, the radiation dose in three different time intervals were measured, first at the time of injection, second half an hour later, during the first scan and third during the second scan. The period of the contact to the patient was measured practically. Maximum and average absorbed dose of nuclear medicine staff through and after a complete scan is shown in tables 2 and 3.

**RESULTS AND DISCUSSION**

The dose rates were measured during three days after the injection. The dose rates variations in different distances from the patients versus time is shown in figures 1 and 2. Three hours after administration of $^{201}$Tl, the average dose rates at the distances of 10, 50 and 100 cm from

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**Table 1.** Administered activity of each radionuclide to patients.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Average age (years)</th>
<th>Age range</th>
<th>Number of patients</th>
<th>Activity (MBq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{201}$Tl-chloride</td>
<td>51.8 ± 9.0</td>
<td>36-68</td>
<td>28 Male, 11 Female</td>
<td>111</td>
</tr>
<tr>
<td>$^{99m}$Tc-MIBI</td>
<td>55.8 ± 12.1</td>
<td>30-76</td>
<td>19 Male, 12 Female</td>
<td>370</td>
</tr>
</tbody>
</table>

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**Table 2.** Average and maximum absorbed effective dose of staff in a $^{201}$Tl Scan from patients at different distances.

<table>
<thead>
<tr>
<th>Distance</th>
<th>10 cm</th>
<th>50 cm</th>
<th>100 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average contact time (min)</td>
<td>13</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Mean</td>
<td>Max</td>
<td>Mean</td>
<td>Max</td>
</tr>
<tr>
<td>Effective Dose (µSv)</td>
<td>1.8 ± 0.4</td>
<td>3.2</td>
<td>0.7 ± 0.2</td>
</tr>
</tbody>
</table>

**Table 3.** Average and maximum absorbed effective dose of staff in a $^{99m}$Tc-MIBI Scan from patients at different distances.

<table>
<thead>
<tr>
<th>Distance</th>
<th>10 cm</th>
<th>50 cm</th>
<th>100 cm</th>
</tr>
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</tr>
<tr>
<td>Mean</td>
<td>Max</td>
<td>Mean</td>
<td>Max</td>
</tr>
<tr>
<td>Effective Dose (µSv)</td>
<td>6.0 ± 1.3</td>
<td>11.0</td>
<td>3.1 ± 0.8</td>
</tr>
</tbody>
</table>
Radiation dose to the nuclear medicine nurses

patients, were 8.3, 2.4 and 1.2 µSv/h respectively. These values are in close agreement to the mean corresponding values of 9.2, 2.5, and 0.9 µSv.h⁻¹ obtained by Mountford et al. (1989). The maximum departure dose rates at these distances were 0.14, 0.04 and 0.02µSv h⁻¹ MBq⁻¹ respectively. The external radiation dose rate from ²⁰¹Tl fell gradually, so that by 48 hours after the administration it was about half of the obtained value immediately after administration. After injection of ⁹⁹ᵐTc-MIBI, a rising of the external dose within 1-3 hours (due to deposition of the activity in the heart) was observed. The maximum departure rate per unit activity at the distances of 5, 10, 50 and 100 cm was 0.12µSv⁻¹·MBq⁻¹, 0.09 µSv⁻¹·MBq⁻¹, 0.03µSv⁻¹·MBq⁻¹ and 0.01µSv⁻¹·MBq⁻¹ respectively. The departure dose rates from the patients' administrated ⁹⁹ᵐTc-MIBI were significant from point of view of the radiation protection only during the first few hours. This observation has a good agreement with result reported by Konishi in 1994.

According to ICRP, the maximum exposure for nuclear medicine staff is 55 µSv per day.

It should be considered that the absorbed effective dose to the staff is not only taking place through exposure from the patient, but other sources such as syringe, radiopharmaceuticals,
which come as increment, are effectible. Therefore the absorbed dose from these sources should be added to the patient dose. These points are also needed to be studied thoroughly.

In conclusion for $^{99m}$Tc-MIBI cardiac studies, significant exposure from the patients are limited to the few hours after administration. In case of $^{201}$Tl administration the dose rates from the patients continues to decrease until three days after the injection. The patients should be recommended to urinate frequently and to urinate before leaving the nuclear medicine department. These data could be considered as a base for calculating exposure dose in close contact during working hours of nuclear medicine staff (Harding et al. 1990).

ACKNOWLEDGEMENT

The authors wish to thank the technical staff of Nuclear Medicine Department and nurses of Rajaie heart center for their valuable assistance during this study.

REFERENCES


