Radiation Exposure to Relatives of Patients Treated with Iodine-131 for Thyroid Cancer at Siriraj Hospital

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Abstract— Thyroid carcinoma patients treated with I-131 are potential source of high radiation exposure to relatives who are knowingly and willingly exposed to ionizing radiation as a result of providing support and comfort to patients undergoing radionuclide therapy. The purpose of this study is to present the results of measurements of radiation doses to relatives who designated to care for non self-supporting patients treated with radioiodine at Radionuclide Therapy Ward, Siriraj Hospital. Twenty caregivers of 20 patients underwent radioiodine therapy for thyroid cancers with a standard protocol were given specific instructions with regard to radiation safety and provided with electronic digital dosimeter (PDM 112) to continuously measure radiation dose received on the daily basis, during three days in the hospital. On the day of patients’ release, in vivo bioassays were performed on caregivers to determine the thyroid uptake estimates. The 3-day accumulative doses to caregivers to patients receiving 5.55 GBq (n=11) and 7.4 GBq (n=9) of I–131 ranged from 37 to 333 µSv and 176 to 1920 µSv respectively depending on the extent and level of supports required. The thyroid uptake estimates in all caregivers were undetectable. Electronic dosimeters indicated a maximum whole-body effective dose of 1920 µSv was more than the public dose limit of 1 mSv but within the general dose constraint of 5 mSv. Radiation dose to caregivers of a non self-supporting hospitalized patient undergoing radioiodine therapy were well below the limits recommended by the ICRP and the IAEA. The patients can be comforted with confidence that dose to caregivers will be below the 5–mSv limit. This study provides guidance for medical practitioners to obtain practical radiation safety concerns associated with hospitalized patients receiving I–131 therapy especially when patients are comforted in the hospital ward by caregivers.

Key Words— radioiodine therapy; caregivers; dose constraints

I. INTRODUCTION

The use of I–131 for treatment of benign and malignant thyroid disease is common practice worldwide. Benefits to patients treated with radioiodine–131 must be balanced against radiation exposure to family member or relatives who designated to care for patients who are non self–supporting and occupational workers. The treatment may be performed with either the patient admitted to hospital or as an outpatient. Under standard guidelines, patients receiving less than 1100 MBq do not require hospitalization [1]. However, radioiodine treatment at high dose on inpatient basis may pose risk to both hospital staffs and patient’s relatives knowingly and willingly incur an exposure to ionizing radiation in the support or comfort of patients who is undergoing medical exposure [2]. The potential risks are from both external irradiation and contamination. Doses to these caregivers must be kept as low as reasonably practicable, and must never exceed the general dose constraint of 5 mSv with a consideration of time, distance, and shielding. The International Commission on Radiological Protection (ICRP) 105 recommended a dose constraint of 5 mSv per episode for carers while young children and infants, as well as visitors not engaged in direct care or comforting, should be treated as members of the public and to keep their dose within the 1 mSv/year [3]. The ICRP Publication 94 [4], IAEA Safety Report Series No. 63 [5] and European Commission [2] recommended dose constraints per procedure per episode of 0.3–1 mSv for pregnancy, children and members of the public; 3 mSv for adult and 15 mSv for adults older than 60 years. Whereas the U.S.NRC recommended dose base of 5 mSv per episode in all age [6]. The purpose of this paper is to present the results of measurements of external and internal dose to caregivers who cared for inpatient treated with radioiodine during 3-day isolation at the radionuclide therapy ward, Siriraj hospital.

II. MATERIALS AND METHODS

A. Dosimeter and gamma spectrometer

1. Electronic personal dosimeter, ALOKA PDM–112
2. Thyroid uptake system, Atom lab 950, Microprocessor-controlled 1024 channel Multi-Channel Analyzer with 2”x2” NaI(Tl) detector, flat field collimator IAEA standard and a personal computer interface, Model Biodex Medical Systems.

B. Patients

Twenty patients (3 male and 17 female), older than 60 years old, were admitted to the radionuclide therapy ward between December 2010 to December 2011 at Siriraj Hospital. They were physically unable to take care for themselves without assistance from comforters or carers. Most of them had difficulty to walk to the bathroom. Nine received 200 mCi and 11 received 150 mCi.

C. Caregivers

Caregivers (2 male and 18 female), aged over 40 to 66 years, of twenty patients hospitalized in the radionuclide therapy ward after high-dose radioiodine therapy (5.55 – 7.4 GBq) were instructed to strictly comply with radiation safety instructions. The radiation risks are discussed and the radiation protection requirements are reviewed with...
both the patient and the caregiver. Caregiver is required to sign an undertaking that he/she will abide by radiation safety guidelines. Emphasis is placed on advising the caregiver to minimize contact with patients and stay behind the lead barrier, with exceptional circumstances, for example more spending time than recommended with a seriously ill patient.

D. Procedures

During the period of this study, caregivers are provided with an electronic personal dosimeter (EPD), ALOKA PDM–112. Cumulative radiation dose throughout a period of 3 d following the administration of I-131 were recorded. Each identified caregiver was instructed to wear the dosimeter clipped to a breast pocket or inserted in a mobile pocket as shown in Fig 1. At night, the dosimeter was to remain at the bedside table of the caregiver. The dosimeter was returned to the Section of Nuclear Medicine after 3 d and the recorded data were analyzed.

Figure 1. Dosimeter positioned in a mobile pocket.

E. In vivo thyroid bioassay

On day of discharge, thyroid screening measurements were performed on caregivers to monitor the intake of volatile radioiodine following the criteria suggested in the IAEA Safety Guide RS-G-1.2 [7]. A thyroid uptake unit, Atomlab 950 PC Medical Spectrometer was used for measuring radioiodine in the thyroid.

The protocol was approved by the Siriraj Ethics Committee for Human Experiment and a written informed consent was obtained from each subject.

F. Statistical analysis

Statistical analysis was done using SPSS 13.0 software for Windows. Comparisons of doses were performed with the unpaired t-test. Data were reported as the maximum, minimum. Statistical significance was set at p<0.05.

III. Results

The cumulative doses to caregivers over 3 days from patients treated with 150 mCi (n=11) and 200 mCi (n=9) of I-131 ranged from 37 to 333 µSv and 176 to 1920 µSv respectively (Table 1). A significant difference (p=0.03) was observed between doses to caregivers from patients administered 5.55 and 7.4 GBq. Figure 1 shows that dose received by 18 caregivers (90%), were less than a dose limit of 1 mSv for general members of the public. The rest 2 caregivers to 7.4 GBq patients (10%) received an external dose between 1 and 2 mSv.

<table>
<thead>
<tr>
<th>Caregivers</th>
<th>Dose received (µSv)</th>
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<tbody>
<tr>
<td></td>
<td>5.55 GBq</td>
</tr>
<tr>
<td>1</td>
<td>333</td>
</tr>
<tr>
<td>2</td>
<td>326</td>
</tr>
<tr>
<td>3</td>
<td>183</td>
</tr>
<tr>
<td>4</td>
<td>157</td>
</tr>
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<td>5</td>
<td>141</td>
</tr>
<tr>
<td>6</td>
<td>135</td>
</tr>
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<td>7</td>
<td>117</td>
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<td>8</td>
<td>81</td>
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<td>9</td>
<td>70</td>
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<tr>
<td>10</td>
<td>38</td>
</tr>
<tr>
<td>11</td>
<td>37</td>
</tr>
</tbody>
</table>

Mean 147.1 653.7
SD 101.7 582.7
Min 37 176
Max 333 1920

Fig. 1. Distribution of caregivers’ dose from patients received 150 and 200 mCi of I-131.

Examples of supporting and caring activities when patients need help and approximate time spent in vicinity of the patients was summarized in Table 2. A maximum dose received in the first 24 hour was 340 µSv and the maximum dose received in close contact to the patient was 365 µSv of which approximately 11 µSv was from helping patient to bathroom, 4 µSv from tube feeding and 28 µSv from
changing diapers for bedridden patient, assisting patients with bathing and emptying and replacing a urinary bag.

Table 2 Dose received from supporting and caring patients

<table>
<thead>
<tr>
<th>Caring activities</th>
<th>Dose received (μSv)</th>
<th>Time spent (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helps patient to bathroom</td>
<td>11</td>
<td>10 – 40</td>
</tr>
<tr>
<td>Tube feeding</td>
<td>4</td>
<td>15 – 30</td>
</tr>
<tr>
<td>Changing diapers for bedridden patients</td>
<td>28</td>
<td>15 – 30</td>
</tr>
<tr>
<td>Assisting patients with bathing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emptying and replacing a urinary bag</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum dose received in the first 24 hour</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>Maximum dose received in close contact to the patient</td>
<td>365</td>
<td></td>
</tr>
</tbody>
</table>

IV. DISCUSSION

Hospitalization of non self-supporting patients for several days can increase exposure of family members designated as caregivers or occupational exposure of hospital staff. The major source of radiation dose to the caregivers is from external exposure. In this study, all caregivers received dose within limit of the IAEA and the European Commission guidance that proposed dose constraints for family and close friends per treatment with I-131 of 3 mSv to adults up to 60 years old [2,5]. Dose limit and dose constraint from the patients after radionuclide therapy has been discussed over many decades. Until lately, the recent publication of the ICRP Publication 94 and IAEA Safety reports series 63[5] recommended a dose constraint to carers and comforters of 5 mSv/episode. Previously, the U.S. Nuclear Regulatory Commission (USNRC), allowing the release of patients immediately after I-131 therapy if the total effective dose equivalent from the patient to an individual does not exceed 5 mSv in any 1 y. With this change, a patient can be treated with a higher amount of I-131 as an outpatient with proper instructions to keep the radiation exposure to other individuals as low as it is reasonably practicable. Radiation dose to caregivers ranging from 0.37 to 1.92 mSv reported in this study are agreeable with many publications.

Grigsby et al. [8] reported the maximum penetrating dose of 0.283 mSv to caregivers to 25 self-help patients receiving 3.7 GBq radiodine outpatient therapy for differentiated thyroid carcinoma for 1 week. Williams and Worward [12] estimated an effective dose of 3.4 mSv over 7 days to nursing staff on dealing with helpless patient undergoing 1 GBq radiodine therapy.

The results of this study and many other studies suggest that radiodine can be a very safe treatment if safety instructions and practices are provided during and after I-131 treatment.

V. CONCLUSIONS

The radiation doses to caregivers from comforting and caring of hospitalized in patients treated with I-131 for thyroid cancer increased with increasing administered dose to the patient. However, they are well below the dose constraint of 5 mSv. This demonstrated that the given radiation precaution instruction is adequate. Radiation dose received depends mostly on the degree of patient’s care requirements and time spent in close contact to the patient. Moreover, dose received by caregivers may be adjusted on caregivers’ decision in compliance with the safety instruction.

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