SQU Med J, April 2010, Vol. 10, Iss. 1, pp. 138-141, Epub. 17th Apr 10
submitted 7th Jan 10

LETTER TO EDITOR

Re: Radiation exposure levels in family members of Omani patients with thyrotoxicosis treated with radioiodine (I-131) as outpatients

Ramamoorthy Ravichandran and Amal Al-Saadi

إشارة إلى : مستويات التعرض للإشعاع لأفراد عوائل المرضى العمانيين المصابين بتسمم الغدة الدرقية والمعالَجين باليود المشع في العيادة الخارجية

رامامورثي رافيجاندران، أمل السعدي

To the Editor

We write in response to the above mentioned article which appeared in the August 2009 issue of SQUMJ.[1] Radiation regulations in most countries permit treatment of thyrotoxicosis using radioactive iodine (I-131) as an outpatient procedure. Hospitals provide instructions to the patients receiving these treatments about the precautions to be observed in their homes in terms of avoiding local radioactive contaminations and also protect other inmates restricting the radiation exposures 'as low as reasonably achievable'. Therefore it is of interest to quantify the radiation exposures incurred from these patients to spouse, children and attendants. Early works- addressed different related issues in this regard.[2-4]

From this objective, we appreciated the work of Al-Maskery and Bererhi reported in your August 2009 issue. The following are the highlights of their work. Their study involved 22 thyrotoxic patients treated on an out-patient basis. Thermo-luminescent dosimeters (TLD) monitoring was carried out on 86 inmates in their homes (29 children and 57 adults). The quantity of I-131 radioactivity administered was 610 ± 79 MBq in the range of 520–862 MBq. Measured mean radiation levels around these patients immediately post-administrations was 23.4 ± 6.3 µSv/h in the range of 13–42 µSv/h. The cumulative radiation doses by other inmates in the homes of these thyrotoxic treated patients during 10 days are shown in two categories. Spouses (n = 11) received a mean radiation dose of 105 ± 152 µSv in the range of 7-425 µSv. Other relatives or attendants received a mean radiation dose of 206 ± 440 µSv in the range of 0–2921µSv.

In Oman, our hospital is another centre where radioactive I-131 treatments for thyrotoxicosis and carcinoma thyroid are offered. From the data of measured exposure rates around these patients, we have obtained the following results.[5] The mean activities administered were 4.19 GBq (in the range of 2.04–9.3 GBq) and 574.7 MBq (in the range of 479–627 MBq) for thyroid cancer and hyperthyroidism treatments respectively. Mean exposure rates immediately after administration of the I-131 therapy doses were 88 µSv/h (n = 69 in the range of 34–184 µSv/h) for thyroid cancer patients, and 14.9 µSv/h (n = 49 in the range of 4.5–34 µSv/h) for thyrotoxic patients. Our study revealed that the radioactive body burden for post-operative thyroid carcinoma had a tri-exponential clearance pattern with $T_{½eff}$ values 14.4h, 22.0h and 41.3h. The body burden of the treated patients for hyperthyroidism cleared with an effective half life $T_{½eff}$ =111.4h. Figure 1 shows the clearance pattern of I-131 with time elapsed post administration in these thyrotoxic patients. With our data accrued from the Omani patients, taking the effective half life ($T_{½eff}$) of clearance in the patients with hyperthyroidism viz. $T_{½eff}$ = 111.4h, we tried to explain the results of cumulative radiation

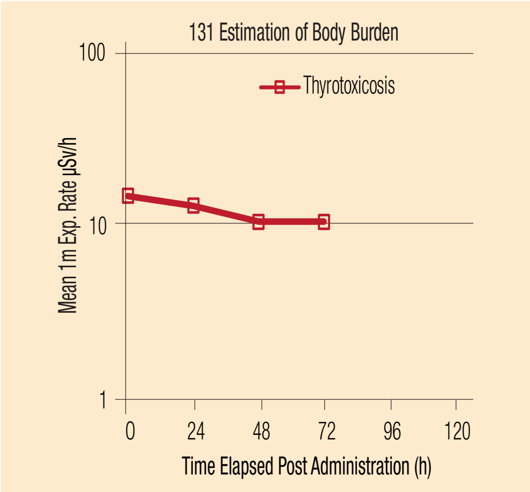

Figure 1: Clearance of I-131 in thyrotoxic patients (n = 49)

exposures received by the inmates observed in the recent study as below.[2]

Method of estimation of radiation level around the patients (for administered I-131 activity 610 MBq):

Dose rate constant for I-131, at 1metre, Γ in mSv. m^2/MBq.hr (Ref. 6) = 7.467 x10^{-5} mSv/h=7.467x10^{-2}µSv/h = 0.07467 µSv/h.

Total emitted dose at 1m from the patient administered with 610 MBq of I-131 = (Activity administered in MBq) x (1.44 times $T_{½eff}$ in hours x (Exposure rate in µSv/h) = 610 MBq x (1.44 x 111.4 hours) x (0.07467µSv/h/MBq) µSv = 7307 µSv

Therefore, if we assume that in 10 days the administered activity of I-131(610MBq) has fully emitted all its emissions, this emitted radiation 7307 µSv at 1m should be taken to represent the cumulated dose received by the individuals moving around the patient in the house. This can be safely assumed because 10 days (240 h) elapsed time duration is nearing 2.5 $T_{½eff}$ eliminating 83% of administered activity.

CALCULATED RADIATION DOSES BY INMATES AT HOME

As the patient has already received instructions, as indicated in Table 1 of the referred work,[1] there will not be permanent presence of other people near the patient. We have to assume some model to explain the local situations around treated patients in their homes. For this, if we take 2 m as reference distance, we can calculate cumulated radiation doses with approximate 'use factors' ¼ (6 hours/Day), ^{1}/12 (2 hours/ Day), ^{1}/24 (1 hour/day).

In these 3 circumstances, the cumulated radiation doses at 2m will be:

(Emitted dose 7307 µSv at 1m) x (Inverse square factor ¼) x (Use factor ¼) = 457 µSv

(Emitted dose 7307 µSv at 1m) x (Inverse square factor ¼) x (Use factor ^{1}/12) = 152 µSv

(Emitted dose 7307 µSv at 1m) x (Inverse square factor ¼) x (Use factor ^{1}/24) = 76µSv

DOSE ESTIMATES

In the above circumstances, the estimates of radiation dose in the reported study[1] for spouses (105 ± 152 µSv in the range of 7 to 425µSv) and other relatives or attendants received a mean radiation dose of 206 ± 440 µSv in the range of 0 to 2921 µSV seems to be realistic. True situations could be approximated within 2 m movement distances in the house, and a representation of 'use factor', as it is conventionally taken to represent approximate situations encountered in health physics calculations, could be assumed. The uncertainties in this communication are: a) the effective half life estimated is based on the mean exposure rates measured on consecutive days in the patients; b) the measured exposure rates are based on beta, gamma survey meters which have inaccuracies in terms of estimated µSv/h, and c) there are difficulties in reproducing true circumstances encountered by the inmates spending time with the patients in their homes.

This communication gives a theoretical account to explain the radiation dose estimates by TL detectors, which could be applicable to the similar earlier report also.[3] Pant *et al.*[3] reported higher doses to the family members from thyrotoxic patients, viz. 0.4 to 2.4 mSv (mean 1.1 mSv) and 0 to 1.9 mSv (mean 0.6 mSv). This report is from India, where the living conditions in homes are different from those encountered in

Oman, as individual patients may be moving in closer proximity to other people at home because of higher population density in cities like Delhi. This type of approximation of 1 m emitted dose around patients is the first of its kind and had not been reported earlier in the literature. More insight has to be given to this hypothesis, for health physics applications with the use of ingested radioisotopes in humans.

To conclude, in this study we simplify the calculation of radiation exposure to patient's family members with a theoretical modelling, by using a fixed factor called 'emitted dose at 1m' around the patient. This data is based on the effective half life of clearance estimated from patients from Royal Hospital.[5] By showing agreement with the estimated exposure by TLD in the referred study,[4] it is opined that I-131 thyrotoxicosis patients can be treated as outpatients with proper instructions provided to them.

References

1. Al-Maskery I, Bererhi H. Radiation exposure levels in family members of Omani patients with thyrotoxicosis treated with radioiodine (I-131) as outpatients. SQU Med J 2009; 9:148–52.
2. Barrington S, Doherty M, Kettle A, Thomson W, Mountford P, Burrell D. Radiation exposure of the families of outpatients treated with radioiodine (I-131) for hyperthyroidism. Eur J Nucl Med 1999; 26:686–92.
3. Pant GS, Sharma SK, Bal CS, Kumar R, Rath GK. Radiation doses to family members of hyperthyroidism and thyroid cancer patients treated with I-131. Radiat Prot Dosimetry 2006; 118: 22–7.
4. Monsieurs M, Thierens H, Dierckx R, Casier K, Baere E, Riddenr L. Real time radiation burden to relatives of patients treated with iodine-131: a study in eight centers in Flanders (Belgium). Eur J Nucl Med 1998; 25: 1368–76.
5. Ravichandran R, Binukumar JP, Al Saadi A. Estimation of effective half life of clearance of radioactive iodine (I-131) in patients treated for hyperthyroidism and carcinoma thyroid. Submitted for Publication. Indian J Nucl Med, 2009.
6. Radiation safety and health physics. In: Cherry SR, Sorenson JA, Phelps ME, Eds. Physics of Nuclear Medicine. 3rd Ed. Philadelphia: WB Saunders, 2003. pp. 427–41.

Ramamoorthy Ravichandran and Amal Al-Saadi
National Oncology Center,
Royal Hospital,
Seeb-Muscat, Oman.
Email: ravichandranrama@rediffmail.com

Author's Response

I am writing to respond to Dr. Ramamoorthy Ravichandran and Amal Al-Saadi's letter of 7th January 2010 regarding our article, *Radiation exposure level in family members of Omani patients with thyrotoxicosis treated with radioiodine as out patients.*[1]

The authors used a radioiodine-131 (I-131) kinetic model (submitted for publication to the Indian J Nuclear Medicine journal) and input data on thyrotoxic patients from our clinical studies to estimate the radiation dose received by relatives at home. They found that the kinetic model gave results that were very similar to our clinic trials. We appreciate the effort of the authors to run the model on our data. Kinetic models of radioiodine are well established and are extensively used to estimate radiation exposures.

When we started radioiodine therapy 20 years ago in Sultan Qaboos University, we knew that kinetic models could be used instead of clinical trials because the models had been and continue to be successfully used in other countries. However, the kinetic models were applied on patients from very different cultures.

Because the social and cultural traditions in Oman were so different, we did not know how patients might react to this new radioactive treatment and so we started by using rather stringent regulations whereby patients remained in hospital until the radiation level at one meter from the patient dropped to 2μSv/h. This policy was derived from the UK guidance notes,[2] which allow an internal body activity limit of 30MBq of I-131 for contact with children. Progressively, we cautiously began to reduce these stringent regulations after making sure that the instructions were generally well followed. We performed two clinical studies[3,1] to better understand patient and relatives response to radiation safety instructions and we are now convinced, especially after this most recent study, that we should treat thyrotoxic patients as outpatients because the radiation dose received by patient relatives is within radiation safety regulations.

Haddia Bererhi
Medical Physics Unit
Department of Radiology & Molecular Imaging
Sultan Qaboos University Hospital
Muscat, Oman

References

1. Al Maskery I, Bererhi H. Radiation exposure level in family members of Omani patients with thyrotoxicosis treated with radioiodine as out patients. SQU Med J 2009; 9:148–52.
2. HMSO. Guidance notes for the protection of persons against ionizing radiation arising from medical and dental use. London 1988.
3. Bererhi H, Constable AR. Radiation exposure levels in ralatives of patients after radioiodine therapy. SQU J Sci Res: Med Sci 2000; 2:87–90.