

ORIGINAL ARTICLE

Exposure rate patterns in ^{131}I therapy inpatients at NIMRA Jamshoro: an 08-year study

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Abstract

Aims Therapeutic use of unsealed radio isotopes with an objective of providing radiation dose to the target or affected tissue has been in clinical practice for more than 70 years. Oral administration of radioiodine is an established therapy for the treatment of differentiated thyroid cancers. To avoid unacceptably high radiation exposures to patients' family members and other related people by applying ALARA (as low as reasonable achievable) principle, patients who administered the therapeutic dosage of ^{131}I are required to be hospitalized for some period until the retained radioactivity in the body or the exposure rate at one meter falls to acceptable levels according to national and international limits. The main aim of this study was to investigate the exposure rate patterns of inpatients administered with therapeutic radioiodine and discuss the associated radiation safety issues.

Methods This work presents the exposure rate patterns in patients treated with ^{131}I at our institute from 2004 to 2011. A total of 83 patients with thyroid cancer treated with different activities of ^{131}I ranging from 50 to 150 mCi were included in this study. 76% of the patients were females and 24% male with an age range of 17 to 70 years.

Results The majority of patients (77.11%) were discharged at the exposure rate of less than 02 mR/hr (milli-Roentgen/hour), whereas only 22.89% patients were discharged at the exposure rate between 02 mR/hr and 05 mR/hr. Only 1.2% of total patients discharged after first 24 hours following ^{131}I administration whereas 33.73%, 25.3% and 21.67% patients were discharged after 48, 72 and 96 hours after the dose administration. Only 1.2% of the patients stayed the longest duration in isolation (264 hours or 11 days) at the hospital.

Conclusion With proper radiation safety measurements and pursuance of instructions, reduction in exposure to family members of patients and public can be suitably achieved.

Key words: *ALARA, exposure rate, isolation room, radioiodine, I-131*

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 2221-0288(201301/01)3:1<29:ERPIIT>2.0.TX;2-M

Introduction

^{131}I is a ß-emitting radionuclide with a physical half-life of 8.1 days. Ernest O. Lawrence in 1931 first constructed the cyclotron, which was later in 1934 used for radiosodium production by Enrico Fermi through bombardment of neutrons on stable iodine [6]. The primary emissions of ^{131}I are ß particles of a maximal energy of 610 keV followed by a gamma rays emission of 364 keV [1-3]. Sodium iodide (^{131}I) was first used in January 1941 by Saul Hertz and Arthur Roberts for treating hyperthyroidism [4] and since then has become a popular treatment option for patients with thyroid cancer. It is a safe and a relatively inexpensive treatment of choice [4, 1, 5].

Patients treated with therapeutic dosages of ^{131}I are potential sources of unacceptable high radiation exposure to other individuals, particularly their close family members. Several standards and policies have been established to regulate the discharge of hospitalized patients receiving radioactive treatment. Generally, the patient is hospitalized until the measured exposure rate at one meter from the patient's body surface falls to acceptable levels [7-9] as per the ALARA principle [10]. The criteria for releasing patients are set to ensure that no one receives exposures above the regulatory dose limits for the general public [7, 11-15]. The main aim of this study was to discuss in detail the issues related to the patients administered with radioiodine as well as the site where the activities of ^{131}I were administered.

Patients and methods

Exposure rate measurement is a crucial factor in discharging patients administered with radioiodine therapy. The exposure rate measurement aims at keeping the radiation exposure to others as low as reasonable achievable [10, 16]. If the administered activity to the patient is more than 30 mCi or if the emitting exposure rate more than 5 mR/hr at one meter from the patient, hospitalization in a special isolation room until the residual activity is reduced to less than 30 mCi or the exposure rate decreases to less than 5 mR/hr is necessary [17, 18].

A total of 83 patients, 63 (76%) women and 20 (24%) men, were administered radioiodine at Nuclear Institute of Medicine and Radiotherapy (NIMRA) Jamshoro. The patients' ages ranged from 17 to 70 years. All the administered ^{131}I activities ranged from 50 mCi to 150 mCi. The dose to individual patient was determined according to a patient's therapeutic requirements. Patients' personal data such as age, sex, administered activity, date and time of administration were recorded. Initial exposure measurements were recorded at the time of administration of activity with daily exposure rate measurements at a distance of one meter including the day of discharge of the patient from hospital [12, 13, 19]. Victoreen Minimonitor II, model 05-571, calibrated at Secondary Standard Dosimetry Laboratory, Pakistan Institute of Science and Technology, Islamabad, was used for exposure rate measurements.

Each patient was briefed about the procedure and written consent obtained [11]. Oral and written instructions relevant to the patient's isolation and stay at home were provided to every patient in order to minimize the dose to others [12, 20, 7, 21, 22]. The instructions included: i) keeping the patient alone in the isolation room during stay at the hospital; ii) allowing caregivers/family members for very short periods to provide meals and water to the patient; iii) ensuring plentiful intake of liquids; iv) oral lemon/orange candies to minimize the dose to salivary glands; v) advising lactating mothers to stop nursing their babies immediately to prevent the babies from ingesting radioiodine excreted into the breast milk; vi) recommending avoidance of pregnancy for a period of 4-6 months after the administration of ^{131}I; vii) instructing the patients to maintain safe distance between themselves and their family members and general public, ensuring separate sleeping

arrangements, avoiding travel by public transport and avoiding visiting public places such as grocery stores, shopping centers, theatres, restaurants and public events; viii) instructing patients and their caregivers to comply with the same set of instructions at home after discharge from hospital for one to two weeks as maintained in isolation room to reduce dose to caregivers/close family members.

The releasing criteria for the patients from isolation was based on the local, national and international regulatory agencies [7, 14, 15]. US Nuclear Regulatory Commission regulatory guide 8.39 [23] explains various options including release of patients based on measured exposure rate of 7 mR/hr at one meter [11, 16, 18, 24, 25].

It has been agreed that the patients may be released when their measured exposure rate is less than 5 mR/hr at one meter [26] and this limit is the regulatory requirements set by PNRA [7]; however, at our institute, most patients were not discharged from the hospital until their exposure rate was 02 mR/hr or even less to avoid unacceptable radiation exposure to family members.

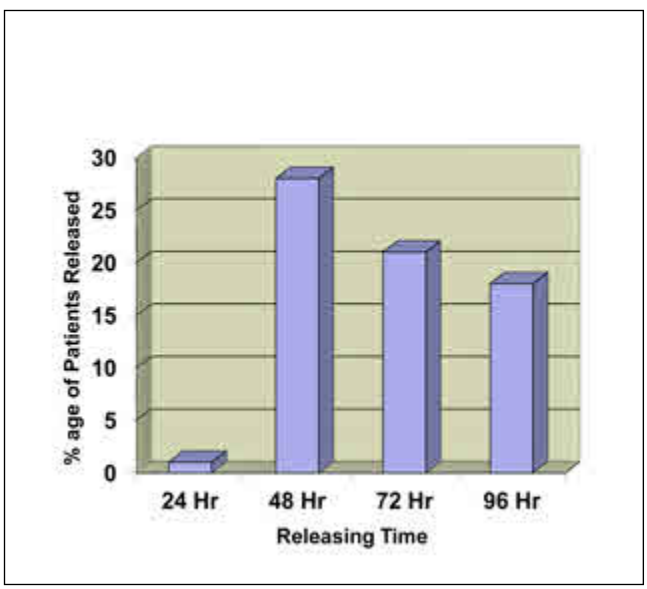

Figure 1 *Percentage of patients released at 24, 48, 72 and 96 hours at NIMRA*

Results

Out of 83 patients, only 1 patient (1.2%) was discharged after first 24 hours after ^{131}I administration, with 28 (33.73%), 21 (25.3%) and 18 (21.67%) patients discharged respectively after 48, 72 and 96 hours after dose administration (Figure 1). One (1.2%) patient stayed 11 days (264 hours) due to radioactivity in the patient's enlarged neck nodes. Figure 2 shows that the majority of patients (64 (77.11%)) were discharged at the exposure rate ≤02 mR/hr, whereas only 19 (22.89%) patients were discharged at the exposure rate ranging from 02mR/hr to 05 mR/hr.

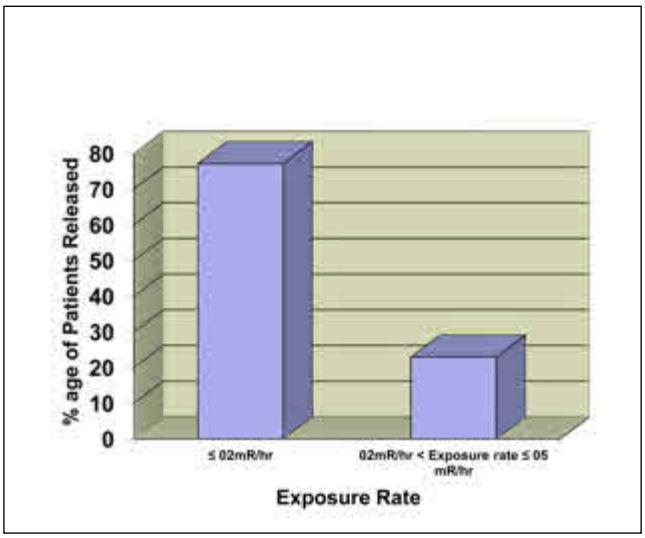

Figure 2 *Exposure rate of patients being released from NIMRA*

Daily decrease in exposure rate shows the elimination of radioiodine from the patients and we have a mixed pattern of patients' exposure rates treated at our Institute. In the first 24 hours, the exposure rate of 67 (80.72%) radioiodine therapy patients dropped to approximately 50% of the initial exposure rate, and after each consecutive 24 hour period, the exposure rates fell to 14.95%, 10.32% and 8.66% as indicated in Figure 3. Overall, there was more than 75% fall in the initial exposure rate during stay of the patients at the hospital. The doses to caregivers/family members during patients' stay at hospital (through providing meals and water

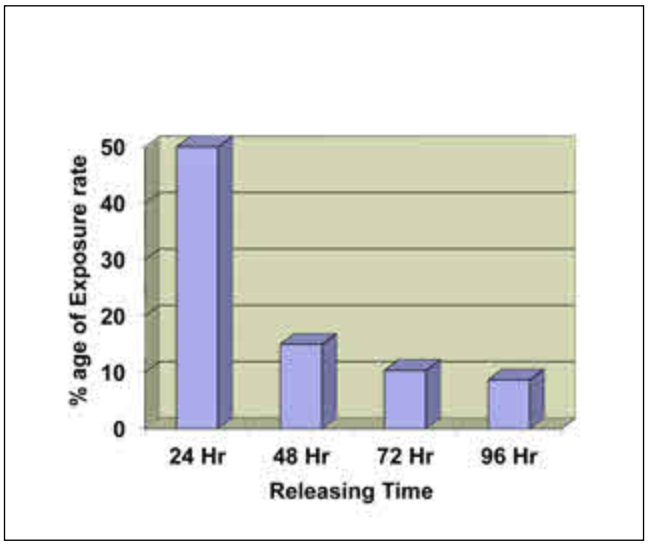

Figure 3 *Exposure rate patterns in our patient population*

to patients in a short time span) were estimated from the daily exposure rate measurements, which ranged from 0.0321 to 0.235 mSv and from this set of data it was estimated that the majority of caregivers (more than 70%) received doses between 0.05 mSv and 0.10 mSv.

The results of this study show that with good radiation safety precautions and radiation protection measures and complying with instructions given to patient administered with ^{131}I, the exposure to family members of patients and general public can be minimized.

Discussion

It is important to consider all matters related to patients administered with ^{131}I at the institute including: activity administered and its elimination from the patient, releasing of patients from isolation, exposure rate and its decreasing pattern, dose received by caregivers/close family members of patients, radiation doses to the general public, and financial burden on the patients and the medical institution where the patients are treated as inpatients.

Since patients administered with therapeutic doses of ^{131}I are a source of radiation exposure and a possible radiation hazard to surrounding individuals, it is particularly important to avoid unacceptably high radiation exposure of close family members of the patients. Therefore, for radiation protection purposes, the radioactive patients are required to be hospitalized for a period of 1-3 day or more until the radioactivity in their body or the exposure rate at one meter parallel to the thyroid, falls to acceptable levels [12, 23].

US Regulatory Guide 8.39 [24] describes the criteria for releasing patients from isolation who have been given ^{131}I therapy doses. Acceptable radiation burden for release include a total-body activity of less than 30 mCi (or an administered dose of <30 mCi) or exposure rates of the patients at one meter at below 5 MR/hr. When one of the criteria is met, the patient may be discharged to home. Since the exposure rate decreases with passing time due to the decay of ingested activity as well as biological clearance, daily surveys are essential. Most of the activity is excreted from the body in urine during the first two days after the radioiodine administration [1, 2, 27, 28]. Uptake and retention of radiation varies from patient to patient. From a safety point of view of the patients' family members and general public, the exposure rate must be considered along with the socioeconomic conditions of patients as many of our patients are financially poor and the resources available to the institution where the patients are being treated are very limited [2]. The radiological protection webpage of the IAEA, prescribes 84-90 percent of the dose of ^{131}I (used for treatment of thyroid disorders) as allowed to be discharged into the public sewer. The site also sets the hospital discharge criteria for patient discharge at 30 mCi or less than 5 mR/hr [8]. In Japan however, the level set level for the same is 14 mCi or less than 3 mR/hr. ARPNSA has set the discharge levels for radioiodine patients at 0.5-4 mR/hr at one meter and also indicated that about 80% of the administered activity are eliminated within the first 48 hours [20].

Culver and Dworkin [26] reported that 26% of the treated patients were released after one day from hospital whereas 67% and 7% were

Table 1 *Summary of different studies on percentage clearance of ^{131}I activity from patients*

Study	Percentage clearance of ^{131}I activity from patients			
	24 hours	48 hours	72 hours	96 hours
Thompson [18]	_	80	_	_
Massimiliano *et al.* [29]	_	80	_	_
Driver and Packer [13]	51	68	76.5	81.5
Tuntawiroon *et al.* [30]	30-75	_	_	_
Parthasarathy and Crawford [31]	30-75	_	_	_
Tavakoli [32]	70	90	96	_
Current study	50	65	75	84

with residual activity of 27.0 ±6.3 mCi and the mean exposure rate of 4.0 ±0.9 mR/hr at one meter from the patient. Table 1 summarizes the results of the different studies on percentage clearance of ^{131}I activity from patients. Regulatory Guide 8.39 [23] as well as Culver and Dworkin [26] prescribed that the patients may be released as the patients' measured exposure rate is less than 5 mR/hr at one meter, but at our institute most patients were kept until their exposure rate become 02 mR/hr or even less. In a study carried out by Al-Maskery and Bererhi [24] it was shown that the radiation exposure levels received by the family members including spouses range from 1.3 to 4.2 mR/hr at one meter from the patients, which are in the range of permissible limits. Bererhi and Constable suggested that the patients may be treated as outpatients for reduction in financial burden in the hospital [33].

Tonnonchiang *et al.* studied the cumulative doses of patients' caregivers/close family members and reported that the dose to caregivers/close family members were less than annual limit to general public which is 1 mSv [34] whereas Grigsby *et al.* evaluated the dose to family members of patients which reportedly ranged from 0.01-1.09 mSv [18]. Rutar *et al.* reported the radiation doses to caregivers/close family members to range from 0.17 to 4.09 mSv [35]. Marriott *et al.* in their study described the maximum penetrating dose to caregivers/close family members in order of 0.283 mSv [36].

Pant *et al.* suggested that patients may be released if the captured activity in the patient drops to less than 16 mCi or the exposure rate at one meter from the patient is 3 mR/hr or less [37]. Muhammad *et al.* discussed the release criteria of radioiodine patients being treated in developing countries like Pakistan and recommended that the limits might be set for releasing patients from isolation as 10 mCi or 1 mR/hr instead of 30 mCi or 5 mR/hr. They underscored the importance of considering both the financial situation of the treating institution and the patient's background into consideration by weighing in such factors as the socioeconomic condition, literacy rate, family situation of the patients, etc. [38]. Panzegrau *et al.* [39] compared the costs of inpatient versus outpatient treatment with same doses along with minimizing exposure to the general public and concluded that the average cost for outpatient treatment was much less than the cost for inpatient treatment which findings were also supported by Zaman *et al.* who reported a 60%-86% reduction in cost of outpatient as compared with inpatient treatment [40]. These studies also imply that in the third world countries it is quite important to consider the economic burden on the hospitals providing ^{131}I treatment to the patients.

Conclusions

The results of this study as that of many other studies suggests that radioiodine is a very safe and effective treatment with good radiation safety

record when instructions given to patients and their close family members during and after treatment are followed so that the exposure to family members of patients and the general public can be minimized. Outpatient treatment incurs much lower cost compared with inpatient treatment [39, 40]. Like several other researchers [18, 24, 34-36], our study has also shown that the radiation dose levels received by the family members of patients given outpatient ^{131}I treatment are within permissible limits and therefore this obviates the need for admission of patients to isolation rooms to avoid unnecessary exposure to close family members. As recommended by the International Commission on Radiological Protection, it is important to to be guided by the ALARA principle but consideration should be give to the economic and social factors [10, 41] when considering patient discharge outside the limits set by the regulatory bodies [7-9] in order to minimize the financial burden on the patients and their families as well as on the treating hospitals. We therefore recommend a relaxation in criteria for releasing of inpatients from hospitals.

Acknowledgements

The authors wish to thank Asrar Ahmad (Senior Scientist) and Nasurrullah (Receptionist) from NIMRA, the Hot Lab technicians (especially Khalid Hussain), the ward staff, and staff of computer section (especially Fawad Mehdi and Muhammad Arshad) for their help and assistance, without which this study could not be commenced and successfully completed.

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