Behavior and Awareness of Thyroid Cancer Patients in Korea Having Non-Hospitalized Low-Dose Radioiodine Treatment with Regard to Radiation Safety

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Abstract

Purpose With the recent increase in incidence of thyroid cancer, non-hospitalized low-dose (NH-LD) radioiodine treatment (RIT) has also increased rapidly. The radioactivity limit that is allowed to be administered without hospitalization depends on individual calculation, based partly on patients' behavior. In this study, Korean patients' behavior in relation to radiation safety in NHLD RIT was surveyed.

Methods A total of 218 patients who underwent NH-LD RIT of 1.1 GBq ^{131}I in a single center were surveyed. The patients underwent RIT with a standard protocol and the survey was performed by interview when they visited subsequently for a whole-body scan. The survey questionnaire included three parts of questions: general information, behavior relating to isolation during RIT, and awareness of radiation safety.

Results After administration of radioiodine, 40% of patients who returned home used mass transportation, and another 47% went home by taxi or in car driven by another person. Isolation at home was generally sufficient. However, 7% of patients did not stay in a separate room. Among the 218 patients, 34% did not go home and chose self-isolation away from home, mostly due to concerns about radiation safety of family members. However, the places were mostly public places, including hotels, resorts, and hospitals. About half of the patients replied that access to radiation safety information was not easy and their awareness of radiation safety was not satisfactory. As a result, 45% of patients wanted hospitalized RIT.

Conclusions In many countries, including Korea, RIT is continuously increasing. Considering the radiation safety of patients' family members or the public and the convenience of patients, the pretreatment education of patients should be enhanced. In addition, the hospitalization of patients having low-dose therapy is recommended to be seriously considered and expanded, with the expansion of dedicated treatment facilities.

Keywords Thyroid cancer · Radioiodine treatment · Behavior · Radiation safety · Hospitalization

Introduction

With the recent increase in occurrence of thyroid cancer, radioiodine treatment (RIT) using ^{131}I has been rapidly increased during the last decade [1, 2]. In addition to the usual high dose for advanced thyroid cancer of over 3.7 GBq, lower-dose RIT is also commonly used for limited thyroid cancer. In countries such as Korea, where the incidence of thyroid cancer has increased rapidly and the dedicated treatment facilities for radioisotope treatment are insufficient, non-hospitalized low-dose (NH-LD) RIT is preferred for thyroid ablation in limited thyroid cancer.

The radioiodine dose limit with which non-hospitalization is allowed is usually determined by radiation safety regulations in most countries. For example, in Korea and the United States (US), patients who may cause other people's radiation exposure to be more than 5 mSv are not allowed for release from hospital isolation by the national regulations [3, 4]. This regulation is based on the recommendations of the International Commission on Radiation Protection (ICRP) [5]. Because the amount of radioactivity that causes other people's exposure to more than 5 mSv is different between

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individual patients, the ICRP recommended that the decision for hospitalization should be individualized.

As a general guideline, the US Nuclear Regulatory Commission (NRC) suggested 1.2 GBq of ^{131}I as the radioactivity limit for non-hospitalized RIT by adopting specific modeling and assumptions [4]. However, in the individualized determination of patient release, it is recommended that “it should not be linked solely to residual activity in the patient but should take many factors into account, including the patient’s pattern of contact with other people, the patient’s wishes, occupational and public exposures, family considerations, cost, and environmental factors” [5]. Most of these consideration factors are related to the patients’ behavior and awareness in relation to radiation safety.

Since the revision of the US NRC Regulatory Guide, several studies have reported that patients’ release is safe for their family members, even with high-dose RIT using 3.7–5.6 GBq of ^{131}I [6–11]. These results are very consistent and reasonable. However, one condition should be guaranteed for them to be extended to the real world. In most of the studies, patients were given instruction on radiation safety and voluntarily agreed to participate in the studies. In such cases, their compliance with the instruction would be high.

Patient behavior and awareness are important factors to determine other people’s radiation exposure, which can be considerably different according to social and cultural conditions of each society. In most Eastern Asian countries like Korea, these conditions and resultant patient behavior are different from those of European countries or the US; population density is higher and contact with family members or other people is more frequent.

In this study, we surveyed the behavior and awareness of all thyroid cancer patients after NH-LD RIT for a certain duration in Korea, to provide basic data for appropriate modeling and assumptions required for patient release recommendations.

Materials and Methods

Patients

From November 2009 to March 2010, thyroid cancer patients who underwent NH-LD RIT in the Seoul National University Hospital were included in the survey. All the patients were scheduled to undergo 1.1 GBq of ^{131}I treatment. Among the 646 patients who were the target of the survey, 218 patients replied.

Survey Methods

The patients underwent radioiodine treatment according to the standard protocol of the hospital. In brief, after a 4-week withdrawal of iodine-containing food and thyroid hormone

replacement, the patients were educated on the radioiodine treatment by a nuclear medicine physician. During the education, written-form instruction relating to radiation safety was given to the patients (Table 1). The patients were administered 1.1 GBq ^{131}I , and 3–4 days later a whole-body scan for ^{131}I was performed. The survey was performed by interview when the patients visited for the whole-body scan, in which they were asked to reply on their behavior during the RIT. The survey questionnaire included three parts of questions: general demographic information, behavior relating to isolation during RIT, and awareness of radiation safety. The questionnaire is shown in Table 2.

All the values were expressed as mean $\pm$ SD, and non-repliers were excluded from the analysis.

Results

Patients

The repliers were 49 $\pm$ 12 (range 21–77) years old and included 53 male and 163 female patients. Most of the patients (85%) were educated for more than 12 years, and their average education period was 13.8 $\pm$ 3.5 years. Average family members were 2.8 $\pm$ 1.2. The average number of RIT experience was 1.8 $\pm$ 0.8, and 41% of patients had no previous experience of RIT.

Isolation Behavior at Home

After radioiodine administration, 143 patients went back home directly. Among them, 40% (57 patients) used mass transportation, such as bus, subway, train, and airplane. The average time of mass transportation use was 88 $\pm$ 69 min. Although not included in the mass transportation users, 47% (66 patients) went home by taxi or in a car driven by another person. Their average journey time was 75 $\pm$ 53 min. The patients who drove home alone constituted 13% (19 patients) (Fig. 1a).

Table 1 Key instructions given to patients regarding radiation safety

Key Instructions
1. Avoid using public transportation on the way back home after administration of radioiodine, if possible.
2. Keep a distance (more than 1 m) from others for the first 2 days.
3. Sleep alone during the first 2 days.
4. Avoid close contact with babies, children, and pregnant women for 5 days.
5. Avoid going out to places where many people gather for the first 2 days
6. Drink plenty of water.

Table 2 Survey questionnaire

Questions
Part 1: General demographic information
- Age, sex, education, number of family members, and residence type?
- How much experience of RIT do you have?
- Do you know the administered dose of radioiodine? If so, what is it?
Part 2: Information acquisition
- How much knowledge about radiation safety do you think you have?
- How do you acquire information on radiation safety?
- How easy is your access to the information?
Part 3: Behavior after RIT
- How do you get home after administration of radioactive iodine?
- How long does it take for you to get home?
- After the RIT, do you go to other places instead of going home immediately?
- (If yes) Where do you go and how long do you stay there?
- (If yes) Why do you go to other places instead of going home?
- How long do you isolate yourself in a separate room to avoid contact with family members?
- What is the duration of close contact (within 1–2 m) with family members a day after RIT?
- What is the eating condition after administration of radioactive iodine?
- Which do you prefer between hospitalized and outpatient-based RIT?

RIT radioiodine treatment

At home, although most of the patients stayed alone in a separate room, 7% (nine patients) did not. Isolation duration in a separate room was generally enough and in some cases somewhat excessive, being 3 days or more in 82% of cases (110 patients) (Fig. 1b). Contact with family members at near distance (1–2 m) was also short enough. However, in some cases it was significant that 14% replied to have been in contact with their families at a near distance for more than 3 h on the first day (Fig. 1c). During the first 3 days after RIT, 96% (193 patients) obeyed the guidance that they should have meals separately.

Self-Isolation Away from Home

After administration of radioiodine, 34% (75 patients) went to places other than home. Among the repliers, the places where they went to included local hospitals (30%), public accommodation such as hotels or motels (31%), resort accommodation (14%), and relatives' homes (25%)

(Fig. 2a). The stay duration in these other places was 4.8 ± 2.4 days (Fig. 2b).

The most common reason why they went to other places after radioiodine administration was concern about the radiation hazard to their family members (73%).

Awareness of Radiation Safety

The information source for the patients' awareness of radiation safety included hospital education before RIT (65%), mass media and portal web sites (14%), online or offline patients' societies (13%), and others. In spite of diverse information sources, the accessibility to an information source was estimated as fairly or very difficult in 45% (Fig. 3a) and 49% of repliers regarded their awareness on radiation safety as not satisfactory (Fig. 3b).

As a result, 45% of patients who underwent NH-LD RIT wanted hospitalization during RIT due to radiation safety concerns.

Fig. 1 Patients' isolation behavior at home. Most of patients returned home by mass transportation or cars driven by others (a). Their isolation period (b) and contact time with family members (c) was generally satisfactory, although there were some problematic cases

Fig. 2 Patients' self-isolation away from home. Seventy-five patients went to other places after RIT, and most of them were public places (a). Most of the patients stayed at the places for 2–4 days (b)

Discussion

In this study, we surveyed the behavior and awareness relating to radiation safety of patients who underwent NH-LD RIT for thyroid cancer in Korea. The results demonstrated that although current NH-LD RIT will not impose significant radiation exposure on others, the patients' behavior was somewhat different from the modeling assumption with which radioactivity limit was calculated by the US NRC; the patients' contact time with family members or other people was considerably longer during travel home, and in some cases also at home. Moreover, about 25% of patients chose self-isolation away from home due to concern for the radiation safety of family members. As a result, 45% of patients wanted hospitalized RIT rather than non-hospitalized RIT for radiation safety concerns and inconvenience.

In determination of patient release after RIT, the most important concern is other people's radiation exposure. To limit the exposure, the administered dose used to be limited to up to 1.11 GBq in the US until 1997. However, since 1997 in the US [4] and 2005 in Korea [3], radiation exposure to other people has been limited to less than

5 mSv instead of limiting the administered dose, according to the ICRP recommendations [5]. In these regulations, exposure from a released patient should be calculated individually by an equation in which the occupancy factor is one of the multipliers for dose determination in addition to the exposure rate constant for a point source, initial activity at the start of the time interval, and physical half-life [4]. From this equation, the general radioactivity of ^{131}I that is allowed to be administered without hospitalization was calculated to be 1.2 GBq [4], which is a very conservative value because physical half-life rather than effective half-life and an occupancy factor of 0.25 were adopted.

In the equation, the occupancy factor is the only individualized factor if an exposure rate constant for a specific radioisotope and a residual activity at the release time are predetermined. An occupancy factor is what accounts for different occupancy times and distances when an individual is around a patient. The US NRC suggested conditions and occupancy factor assumptions related with the conditions [4]. In this suggestion, a patient's behavior is the most important factor for adoption of an occupancy factor. For example, the following conditions should be met in order that an occupancy factor of 0.25 may be used; maintenance of a prudent distance from others for at least the first 2 days, sleeping alone in a room for at least the first night, no travel by airplane or mass transportation for at least the first day, no travel on a prolonged automobile trip with others for at least the first 2 days, sole use of a bathroom for at least the first 2 days, and drinking plenty of fluids for at least the first 2 days.

In this study, we surveyed patients' behavior relating to the occupancy factor, and found that some conditions of the US NRC for an occupancy factor of 0.25 were not met in the surveyed Korean patients. First of all, 87% of the patients used mass transportation or cars driven by other people for 80–90 min when they went back home. It may impose a considerable radiation exposure on the accompanying people, because the distance between a patient and accompanying people is usually less than 1 m in mass transportation or family cars. At home, most of the patients isolated themselves according to instructions, sufficiently or even in excess, for not less than 3 days. However, 7% of the patients could not stay at a separate room for various reasons, and 14% of the patients had contact with their family members at a close distance for more than 3 h on the first day.

It will be similar in most Eastern Asian countries including Korea, where more crowded and family-oriented lives are natural. Although this condition does not result in excessive dose to family members of over 5 mSv, the safety margin of the calculated value would get narrow. In addition, repeated effect should also be considered. Even

Fig. 3 Patient information access and awareness in relation to radiation safety. About half of the patients replied that access to information was not easy (a), and their awareness of radiation safety was not satisfactory (b)

if radiation exposure of an individual from a patient does not exceed 5 mSv in the calculation, it is the result for a single RIT. Because it is common to perform RIT twice or even thrice in a year, the accumulated exposure of other people is actually larger than that from a single RIT.

In several previous studies in which radiation exposure of family members were directly measured, the exposure was usually within the recommended limit. When the patients were released 2–3 days after administration of 3.7–5.55 GBq ^{131}I , the radiation exposure of family was 0.106 ± 0.087 mSv [6]. Even when the patients were released directly after administration of high-dose ^{131}I (2.8–5.6 GBq), the highest exposure of family members was measured around 1 mSv [7–10]. These are very consistent and reasonable results, because the patients were expected to show good compliance with radiation safety instructions. However, in a more large-scale study, there were some exceptional cases in which the exposures were over 1 mSv, although the usual radiation exposure was less than 1 mSv [11]. In the study, especially in the groups that used mass transport for the trip back home, 22–27% of family members showed radiation exposure of over 1 mSv. Therefore, family members' radiation exposure can be a concern in specific conditions.

Another point to be considered is public radiation safety. With increase in incidence of thyroid cancers, RIT has been markedly increased. Shortage of radioisotope treatment facilities and increase in early stage thyroid cancers also prompted an increase in NH-LD RIT. In Korea, 11,602 cases (41% of all RIT) of NH-LD RIT were performed in 2009, which was a markedly increased number in comparison with 4,015 cases (30% of all RIT) in 2005 [2]. As a result, collective public radiation exposure is also expected to be increased. Moreover, a considerable number of patients chose self-isolation away from home in this survey. Although self-isolation from home is beneficial for reduction of occupancy factor and radiation exposure of family members, its effect on public radiation exposure may be different because the places of self-isolation included public accommodation, resort accommodation, and local hospitals that had no specific facility for RIT. In addition, a considerable number of patients replied that they were free to go out from home when they were staying at home. Therefore, the influence of NH-LD RIT on public radiation safety is recommended to be reevaluated, based on the results of this study.

In addition to radiation safety issues, the patient's wishes, cost, and environmental factors are also the points to be considered [5]. In this survey, about half of the patients replied that access to information on radiation safety was not easy and their level of awareness was not satisfactory, in spite of standard education of the hospital before RIT. Consequently, 45% of patients who underwent

NH-LD RIT wanted hospitalized RIT for radiation safety concerns and convenience. Their wishes should also be considered in the determination of hospitalization.

Based on the 50-year history of RIT in Korea, RIT has been markedly increased, and new radioisotope treatments are also under active development. With the increase and development, dedicated treatment facilities in Korea have been gradually increased from 57 beds in 2007 to 105 beds in 2010. However, it is still insufficient to meet all the need for RIT, and the number and proportion of NH-LD RITs are increasing. The results of this study suggest that the administered dose is not the only factor to be considered. Also, in low-dose RIT, using less than 1.2 GBq ^{131}I , hospitalization of patients should be seriously considered and expanded according to the condition and wishes of the patients. In such cases, short-term hospitalization of around 1 day would be enough because effective half-life is very rapid [12]. For this, a dedicated treatment facility should also be sufficiently supplied according to appropriate expectation.

Conclusion

In this study, patients' behavior and awareness in relation to radiation safety were surveyed for NH-LD RIT in Korea. The results demonstrated that the safety margin of other people's radiation exposure would be narrower than that assumed by calculation, although radiation exposure in most cases would be within regulation limit. Patients' concerns about radiation safety and self-isolation from home were also considerable. Moreover, 45% of patients wanted to be in hospitalized isolation during RIT. Therefore, pretreatment education of patients with regard to radiation safety should be enhanced. In addition, hospitalization of patients in cases of low-dose therapy is recommended to be seriously considered and expanded, with expansion of dedicated treatment facilities.

References

1. Jung KW, Park S, Kong HJ, Won YJ, Boo YK, Shin HR, et al. Cancer statistics in Korea: incidence, mortality and survival in 2006–2007. *J Kor Med Sci*. 2010;25:1113–21.
2. Korean Society of Nuclear Medicine. 2009 Annual statistics report on nuclear medicine studies in Korea. In: Data Archive. Korean Society of Nuclear Medicine. 2010. <http://www.ksnm.or.kr/member/pds/stat/>. Accessed 2 Aug 2010.
3. Ministry of Education, Science and Technology. Rule of technical standard for radiation safety control in medical affairs. In: Law Information. Korean Ministry of Education, Science and Technology. 2009. http://www.mest.go.kr/me_kor/inform/statute/rule/index.jsp. Accessed 2 Aug 2010.
4. Office of Nuclear Regulatory Research. Regulatory guide 8.39 Release of patients administered radioactive materials. In: Regulatory Guide. U.S. Nuclear Regulatory Commission. 1997. <http://www.nrc>.

- [gov/reading-rm/doc-collections/reg-guides/occupational-health/rg/](http://www.gov/reading-rm/doc-collections/reg-guides/occupational-health/rg/). Accessed 2 Aug 2010.
5. International Commission on Radiological Protection. Release of patients after therapy with unsealed radionuclide. *Ann ICRP*. 2004;34:29–52.
 6. Korea Institute of Nuclear Safety. Radiation dose to family members of patients treated with ^{131}I . Korea Institute of Nuclear Safety. 2009. http://www.kins.re.kr/include/report_down.asp?p_seqno=759 Accessed 2 Aug 2010.
 7. Grigsby PW, Wiegel BA, Baker S, Eichling JO. Radiation exposure from outpatient radioactive iodine (^{131}I) therapy for thyroid carcinoma. *JAMA*. 2000;283:2272–4.
 8. Venencia CD, Germanier AG, Bustos SR, Giovannini AA, Wyse EP. Hospital discharge of patients with thyroid carcinoma treated with ^{131}I . *J Nucl Med*. 2002;43:61–5.
 9. Park HM, Jang JW, Yang HC, Kim YG. Outpatient radioablation therapy for thyroid cancer patients with minimal radiation exposure to the family members. *Nucl Med Mol Imaging*. 2007;41:218–25.
 10. de Carvalho JW, Sapienza M, Ono C, Watanabe T, Guimaraes MI, Gutterres R, et al. Could the treatment of differentiated thyroid carcinoma with 3.7 and 5.55 GBq of (^{131}I)NaI, on an outpatient basis, be safe? *Nucl Med Commun*. 2009;30:533–41.
 11. Pant GS, Sharma SK, Bal CS, Kumar R, Rath GK. Radiation dose to family members of hyperthyroidism and thyroid cancer patients treated with ^{131}I . *Radiat Prot Dosimetry*. 2006;118:22–7.
 12. Park SG. Effective half-life of I-131 in patients with differentiated thyroid cancer treated by radioactive I-131. *Nucl Med Mol Imaging*. 2008;42:464–8.