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A survey of radiation released from patients treated with radioiodine-131 therapy

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ABSTRACT

Background: Radioactive iodine 131 (I-131) is used as an alternative to treat thyroid cancer. Patients receiving I-131 must be separated in provided hospital rooms until radiation level falls below the specified threshold. The knowledge of the amount of radiation in patient rooms along with outlying areas, together with the building's sewer systems will help monitoring and controlling the radiation hazard.

Objectives: This study was conducted to investigate the radiation exposure from ward of patients treated with I-131, and the effects upon general public.

Materials and methods: OSL devices were placed on the outer surface of sewer line and external walls of patient rooms. Accumulated radiation was measured for a period of one month.

Results: The results showed that radiation exposure from I-131 patient rooms located on the 5th floor of Srinagarind Hospital was 7.24 µSv/hr. However, the radiation detected from both sides of drainage pipe were unequal. Radiations on the 2nd, 3rd, 4th, and 5th floors were 1.70, 1.28, 2.97, and 7.24 µSv/hr, respectively.

Conclusion: It could be concluded that accumulated radiation in a single year exceeded the ICRP specified limit and poses a safety hazard for staff and general public. Recommendations to rectify the problem included increasing awareness of staff and public through warning signs, as well as adding of lead shields surrounding the patient rooms. Nonetheless, further measurements should be performed again after reconstruction.

Introduction

Radioactive iodine-131 (I-131) is orally or intravenously administered to patients for the treatment of hyperthyroidism and thyroid cancer. The radiation dosage for hyperthyroidism treatment is about 1 GBq, while treatment of thyroid cancer patients requires a higher I-131 radiation dosage of about 3-6 GBq.[1] During the period in which patients are admitted as hospital in-patients, the measured dose rate outside the room or public area should not be higher than 6 µSv/hr. To protect the public, it is required to isolate these patients until the retained radioactive drug in the patient's body is below 1 GBq, or the measured dose rate from the patient is lower than 5 µSv/hr at one meter. The maximum activity at which a patient is allowed to return home depends on the national practice and individual patient's condition, where it usually ranges between 0.2 and 1 GBq.[1]

The excretion of radioiodine from the patient subsequently enters the hospital's sewer system as waste, which is carried away from the patient ward and may be harmful to staff, relatives, patients, and the general public.[2, 3] There are various recommended methods for the management of these kinds of waste. The most convenient method is to dispose the

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patient's excretion of radioiodine directly into the public sewer system. However, the International Commission on Radiological Protection (ICRP) (1990) has suggested to reduce the dose disposed to the public sewer system to an acceptable level.[4] Therefore, the I-131 treatment ward and the radioactive waste water management system must be specially designed and certified to meet the national radiation safety standard by Office of Atoms for Peace (OAP), Thailand. Moreover, hospital's sewer systems that have been used for a long period of time are subjected to deteriorate and require regular maintenance.

The physical properties of I-131 include its decay through beta and gamma emissions. The decayed beta particles produce a maximum energy of 606 keV (89% abundance, 248-807 keV), and the 364 gamma-ray emits 81% abundance and 723 keV.[2, 5-7] Because beta particles have a shorter range in tissue, the ionizing effects of beta-radiation are restricted to the cancer cells. However, high-penetrating gamma radiation can escape the patient's body, leading to unwanted exposure to those around them.[3, 7-9]

Our study aims to investigate the radiation exposure from the radioiodine therapeutic ward. I-131 is released from the treated patient into the environment, such as building, corridor, staff room, and untreated patient rooms, as well as the sewage waste drainage system.[2, 3, 9] OSL dosimeters were used to measure radiation emitted from the I-131 therapeutic patients' ward.

Materials and methods

InLight® dosimetry systems using optically stimulated luminescence (OSL) were installed at 17 points, two pieces each, totaling to 34 pieces. This provides users with reliable and accurate radiation monitoring (Figure 1). The system measures radiation via aluminum oxide doped with carbon (Al_2O_3: C), and the detectors read optically through stimulated luminescence.[10, 11] The OSL devices were mounted on 1) corridor, staff room, and patient rooms adjacent to the rooms treated with I-131 on the 5^{th} floor; 2) sewer line connected to the exposed rooms; and 3) patient rooms and adjacent rooms on the 4^{th} floors of the building in Srinagarind Hospital. The accumulated radiation was measured for a period of one month. InLight Automatic Reader® (Ionizing Radiation Metrology Group, Office of Atoms for Peace, Bangkok, Thailand) was used to measure the radiation received by the OSL dosimeters (Figure 2).

Figure 1. *OSL dosimeters installed on different places to measure radiation doses.*

Figure 2. *InLight Automatic Reader®.*

Results

Twenty-eight patients, between the ages of 17 and 78 years were treated with radioactive, I-131 at levels between 3.7 - 7.4 GBq. The total radiation activity was approximately 166.5 GBq. Table 1 shows that the exposed radiation level from the I-131 patient room located on the 5th floor was between 0.09-5.21 mSv/month, or 0.12-7.24 µSv/hr (Figure 3). The amount of radiation from both sides of the sewer drainage pipe were unequal. Radiation results on the 2nd, 3rd, and 4th floors were between 0.19-2.14 mSv/month, or 0.26-2.97 µSv/hr (Figure 4).

Table 1 Maximum radiation levels measured in different layers.

Area	Staff room mSv/mo.	Patient room mSv/mo.	Corridor mSv/mo.	Patients who do not receive I-131 mSv/mo.	Waste drainage area mSv/mo.	
					Left wing	Right wing
5th floor	1.48	5.21	0.47	0.09	n/a*	n/a*
4th floor	n/a*	n/a*	n/a*	0.46	0.73	2.14
3rd floor	n/a*	n/a*	n/a*	n/a*	0.28	0.92
2nd floor	n/a*	n/a*	n/a*	n/a*	0.19	1.23

**n/a means: no measurement according to no specified area on that floor.*

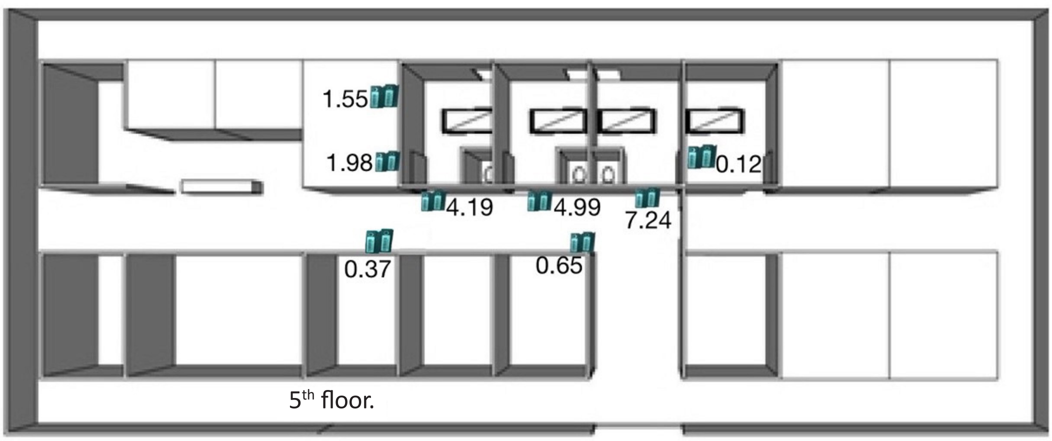

Figure 3. *Placement of OSL plates used to measure radiation on the 5th floor.*

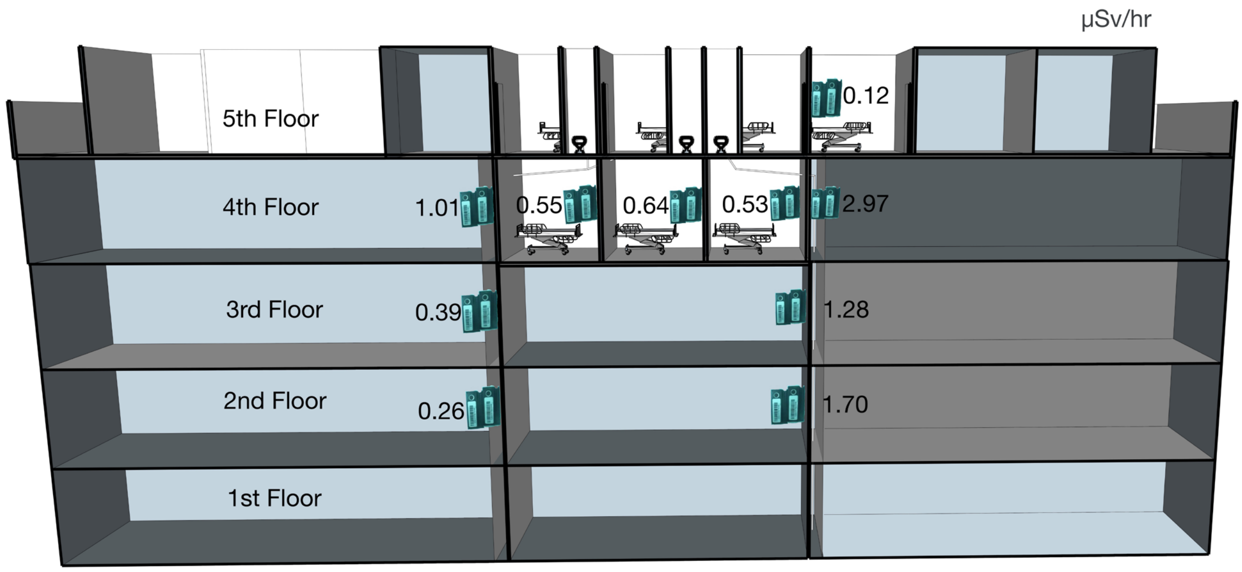

Figure 4. *Positions of OSL plates used to measure the amount of radiation along the sewer line and patient rooms adjacent to I-131 treated rooms on the 2nd through 5th floors.*

Discussion

The cancer treatment ward at Srinagarind hospital is located on the 5th floor of a five-story building. Thyroid cancer patients receiving I-131 treatments are distributed into six patient bends in three rooms. Patients treated with high levels of radioactive I-131 generally remain as in-patients until their radiation level is lower than 5 µSv/hr at 1 meter.[2, 6, 8] In 2017, a total of 275 patients received radiation doses total of 1,472 GBq/year. This high radiation activity may be harmful to people and the environment. Our study examined the radiation levels emitted from radiotherapy patients and their effects upon adjacent areas. We determined that patient rooms involved in the administration of I-131, along with the connecting sewage system were not designed to prevent the ramifications of the radiation therapy. Our study, which we believe to be the first to employ OSL measurements in radiation detection, strives to identify as well as offer solutions to these radiation levels; which can be harmful to staff, relatives, and the general population.

In 2014, Memon SA, *et al*. had conducted a study to record and examine the exposure rates of I-131 to the general public in the corridors and within the non-radioactive patients in adjacent rooms; calibrated by an LAMSE RM1001-RD survey meter. The average exposure rate in the corridors was about 5.17 µSv/hr (2.14 µSv/hr to 8.15 µSv/hr), and the cumulative exposure level of nonradioactive patients residing in adjacent rooms was 0.647 mSv (0.192 mSv to 1.664 mSv). The exposure rates to the general public, especially those non-radioactive patients admitted in adjacent rooms, were slightly beyond the acceptable limit (1 mSv) as specified by both national and international standards.[2]

The current study determined that the adjacent, untreated I-131 patient rooms and staff rooms on the 2nd to 5th floors of Srinagarind Hospital, as well as the associated waste pipeline, exhibited levels of radiation in excess according to the ICRP recommended limits. Levels affecting the public (>1 mSv/y) and the hospital staff (>20 mSv/y)[12] have prompted the necessity to advise them of the associated health concerns, specifically to children and women during pregnancy or breastfeeding; and to reduce radiation exposure levels,[2, 3, 6, 7, 9] as provided by the guidelines and restrictions provided by the IAEA (Safety Report Series 63).[13]

Conclusion

The accumulated results of the radiation exposure determined through our study, ranging from 1.08 - 62.52 mSv/y, exceed the safety limits recommended by the ICRP, which produce an unsafe environment for other patients, staff, and general public. We recommend that lead shields should be added to each thyroid cancer patient room, and warning signs should be posted to alert the general public. We further recommend that radiation exposure measurements should be carried out regularly along with associated water leakage (through sewage) inspections.

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