# Radiation Safety Precautions in the Management of the Hospitalized $^{131}$I Therapy Patient

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***Objectives:*** The patient who has been dosed with therapeutic activities of $^{131}$I for thyroid carcinoma poses a unique set of problems for nuclear medicine technologists in their efforts to reduce personnel exposure and control contamination spread. It is the objective of this article to: (a) review practical radiation safety concerns associated with hospitalized $^{131}$I therapy patients; (b) propose preventative measures that can be taken to minimize potential exposure and contamination problems; and (c) review pertinent federal regulations that apply to patients containing therapeutic levels of radionuclides.

***Key Words:*** $^{131}$I therapy; radiation safety precautions; radiation safety; radiation therapy patient precautions

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Perhaps one of the more common radionuclide therapies performed by nuclear medicine departments is the administration of $^{131}$I for thyroid ablation in the treatment of thyroid cancer. Therapeutic doses of $^{131}$I are administered orally in liquid or capsule form, with the liquid form requiring greater care in handling. Federal regulations specifically address safety requirements in working with such patients, and the United States Nuclear Regulatory Commission (USNRC) has produced Regulatory Guide 8.39 (*1*), which outlines conditions for patient release. Individual agreement states have specific regulations that may be more stringent than the federal regulations previously cited. It is, therefore, most important that the technologist working in an agreement state becomes familiar with state regulations regarding patients containing therapeutic levels of radionuclides to ensure regulatory compliance. Additionally, federal and state regulations are subject to change and the technologist is advised to keep abreast of the changes.

When considering radiation safety precautions for attending personnel, members of the general public, and patients in adjacent rooms, it is important to remember that $^{131}$I emits both negative $\beta$ particles (maximum energy approximately 807 keV) and a prominent 364-keV gamma photon. It is the $\beta$ that delivers the major portion of the radiation dose to the remnant thyroid tissue, and it is the penetrating gamma that poses a potential radiation hazard to others outside the patient's room. In addition to personnel irradiation, external and internal contamination are potential hazards to personnel entering the patient's room after dose administration. Once the patient is dosed, regulations may require a short period of isolation in the medical facility, typically 2 to 3 d, until radiation exposure rates drop to acceptable levels. It is during this time that the greatest potential exists for contamination and radiation exposure problems. Thoughtful planning, adequate radiation safety education for attending personnel, and proper precautionary measures taken by the technologist can minimize potential problems associated with such therapies.

To properly evaluate the extent of potential problems associated with therapeutic oral doses of $^{131}$I, we recall the biological behavior of $^{131}$I-labeled sodium iodide. Upon administration of the dose, the labeled compound is readily absorbed from the gastrointestinal tract and is distributed in the extracellular fluid of the body, concentrating in remnant thyroid tissue, the stomach, and salivary glands, with a portion recirculated back to these tissues. For most patients, some 35%–75% of the administered dose can be expected to be excreted in the urine, perspiration and saliva within the first 24 h after dosing (*2*). From a practical radiation safety perspective, moderate to high exposure rates could be expected to originate from the patient's body and to drop continuously over the course of the isolation period. The actions and recommendations made in this article are based on both federal regulations and more than 20 y of experience at a major health science center where these therapies are performed routinely.

## INITIAL PREPARATIONS

Radiation safety instruction for the patient and the attending nursing staff is the key to contamination control. Patient instruction should include basic topics such as the dosing procedure, actions the patient can take to minimize room contamination, the disposal of waste and food trays, avoiding contamination of personal items, ways to assist the nursing staff, instructions to visitors (if allowed), and ways

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to reduce radiation exposure to family members upon returning home.

Documented radiation safety instruction is required for attending personnel (*3*). Topics covered must include: patient control; visitor control; proper techniques for entering and exiting the patient's room to minimize the spread of contamination; proper use of the Geiger-Mueller (G-M) detector to survey hands and shoes for contamination; who to contact in the event of a medical emergency involving the therapy patient; and radioactive waste control. In addition to providing periodic training sessions for attending staff, videotapes and safety manuals should be made available and left at the nurses' station for reference.

It is most important that attending staff be assigned personnel dosimetry devices (to provide a legal record of radiation dose received) and that thyroid bioassays be performed and the results documented, preferably within 24 h of the therapy's conclusion. Neither pregnant members of the nursing staff nor female nurses who make it known to their supervisors that they are trying to conceive should attend an $^{131}$I therapy patient. (Note: The possibility of internal contamination with $^{131}$I is especially hazardous for these individuals since radioiodine, if taken internally by the mother, can cross the placental barrier and destroy the fetal thyroid in addition to providing excessive radiation dose to the fetus.) Once your attending staff has been trained in radiation protection, it is preferable to use the same individuals for future therapies.

Room selection and preparation are also very important. First choice is a private room, preferably lead-lined to reduce exposure rates in hallways and to patients in adjacent rooms from the 364-keV and higher energy photons. If a lead-lined room is not available, a room with thick concrete walls will suffice. In either case, the room should not be carpeted, should be isolated and away from high-traffic areas, and should be located at the end of a hallway to reduce radiation exposure to other patients. It is also mandatory that the room has its own private bathroom facilities.

Once the room has been chosen, the extent of room preparation varies among facilities. Recognizing that the room and its contents are likely to become contaminated, some medical facilities may choose to cover the entire floor area with absorbent bench paper to minimize room clean up at the conclusion of the therapy. Other facilities may strategically place strips of absorbent bench paper on either side of the bed, one piece leading to the door, and one leading to the bathroom. It should be noted that in the event of a major spill during the course of the therapy, clean up is much faster if the floor area is completely covered. The contaminated area can be cut out and recovered with clean bench paper. Likewise, at the conclusion of the therapy, room decontamination is faster and more thorough if the floor is completely covered. In addition, telephone receivers, TV remote controls, light switches, and nurse call devices should all be covered with plastic to reduce their chances of contamination. The use of a disposable plastic mattress cover is also recommended.

Regardless of which of the methods described is used, particular care must be taken in the preparation of the bathroom facilities. This will be the site of greatest contamination. The patient bathroom floor should be completely covered in absorbent bench paper or absorbent pads. The toilet seat and sink handles should be covered with plastic. Relatively high levels of contamination will also exist in the sink and drains. If greater care is taken initially to prepare this section of the isolation room, less time will be required in its decontamination to NRC regulatory limits of less than 200 dpm per 100 cm$^2$ for release of the room for use by other patients (*4*).

The taping of an absorbent bench pad on the floor just outside the entrance to the patient's room can serve as a reminder to attending nursing staff to remove their contaminated shoe covers before stepping onto the absorbent pad. Nursing staff should be properly instructed before patient dosing that personal protective equipment (disposable surgical gown, 2 pairs of gloves and shoe covers, and a surgical mask) must be worn when entering the patient's room. Each of these items must be properly removed when exiting, and stored in a designated location for pick-up by nuclear medicine or radiation safety personnel. These items are now considered to be contaminated. A radiation isolation cart containing all required items (Table 1) should be positioned just outside the patient's room and periodically checked to ensure an adequate supply of all items.

Because of the high potential for contamination spread, no visitors should be allowed in the room once the therapy has begun. Visitor policy may vary from one institution to another, but a "no visitor" policy is strongly recommended as a means of implementing the "as low as reasonably achievable" (ALARA) concept. If visitation is allowed, it is best to restrict visits to immediate family members over 18 y old who are not pregnant or possibly pregnant. A visitor's chair could be positioned just inside the isolation room door with strict visitor time limits and safety instructions. Exposure rates must be measured at the visitor's chair and time limits set to assure that, for the duration of the

**TABLE 1**
Recommended Items for a Radiation Isolation Cart

| |
|---|
| Disposable surgical gowns |
| 2 boxes of disposable shoe covers |
| Boxes of disposable latex gloves (all sizes) |
| Disposable surgical masks |
| 2–3 boxes of small filter papers (for wipe tests) |
| Scissors |
| Tape (masking tape and radiation warning tape) |
| Large garbage bags (for collection of contaminated items) |
| G-M detector |
| Permanent marking pens |
| Decontamination cleansing solution (a dilute solution of liquid dishwashing detergent and water) |

therapy, the visitor's dose does not exceed the annual limit for the general public of 1 mSv (0.1 rem).

Arrangements must also be made for meals to be served on disposable food trays with disposable utensils throughout the course of the isolation period. Disposable food trays and any other contaminated items can be temporarily stored in trash bags in the isolation room, where they are to be removed for proper disposal only by radiation safety or nuclear medicine personnel. A separate storage container should be made available for linens and other reusable items, which can be stored and allowed to decay to background levels. These items should be stored for approximately 90 d for $^{131}$I and surveyed with a G-M detector to assure no detectable radiation before their release for disposal. It should be emphasized to nursing and housekeeping staff that once the therapy has begun, no items are to be removed from the room unless first cleared by nuclear medicine or radiation safety personnel.

## PATIENT PREPARATION

Because of the contamination problems associated with this therapy procedure, patients should be provided with scrubs to wear for the period of isolation. Personal clothing should not be allowed until the day of patient release from isolation. This minimizes the probability of contaminated clothing taken home by the patient, thereby reducing radiation exposure to family members. Disposable personal grooming items (e.g., toothbrush, comb, hairbrush, razor) are also recommended. Books, magazines, or any other items in the room after dose administration will be disposed of as radioactive waste or will be stored and allowed to decay for at least 90 d at the conclusion of the isolation period.

It is also good practice to inquire as to the current state of health of the patient before dosing. If the patient is coughing or sneezing, this could lead to the increased chance of contamination of personnel and room contents, and will likely require more extensive room preparation. An incontinent patient would present major contamination problems unless catheterized. In addition, the catheter bag must be adequately shielded to reduce exposure to attending personnel (Note: A makeshift shield could be constructed using plastic or acrylic as the inner lining wall and at least a 5mm-thick lead outer wall. The plastic would minimize bremsstrahlung production, and the lead would provide at least a 2 half-value layer reduction in exposure resulting from photon radiation.)

If blood or urine specimens are to be collected, collection should occur before the radionuclide is administered. Of course, if medical conditions dictate the need for specimen collection during the isolation period, then collection should not be denied. However, samples should be clearly labeled as radioactive. After release from isolation, specimen collection may continue without special precautions.

All female patients of childbearing age must be given a pregnancy test, and the results must be documented. A patient who is a nursing mother must be informed of the need to discontinue or interrupt breastfeeding until there is no $^{131}$I remaining in the mother's milk. Radiation doses delivered to an infant or developing fetus as a result of this type of therapy can be potentially devastating. It is, therefore, most important that the consequences of not following these precautions be strongly emphasized to the patient, both verbally and in print (*1,5*). The issue of instructions to patients is also discussed in the *USNRC Regulatory Guide 8.39* (*1*), which is available on the Internet at the NRC web site (*6*). If a patient is a nursing mother, the mother should prepump enough breast milk before the therapy or wean the infant to formula. Weaning the infant to formula several weeks before the therapy is preferable, because the resulting reduction of the volume of milk in the breast has the added advantage of greatly reducing the radiation dose to the mother's breast.

Because most patients are somewhat apprehensive about being exposed to radiation, special attention to patient education can be most helpful in allaying fears and obtaining a higher degree of patient cooperation during the therapy. Most patients would appreciate a brief visit by the technologist or physician who will be administering the dose before the time of dosing to explain the procedure and answer questions.

## DOSE ADMINISTRATION

At the designated time, the dose to be administered is brought on a cart to the patient's room in its shielded shipping container. Before administration of the dose, the technologist must ensure that all aspects of the therapy have been explained and that the patient has signed the therapy consent form. Once this has been confirmed, the dose can be administered. All contamination precautions must now be observed—2 pairs of shoe covers, 2 pairs of gloves, a surgical gown, a mask and optional hair cover should be worn by all who enter the radiation isolation room.

The dose may be in capsule or liquid form, depending on physician preference. Studies have shown that absorbent materials used in the packaging of $^{131}$I capsules can be sources of $^{131}$I contamination (*7*). As when working with any volatile radionuclide, the capsule container should be initially opened in a properly vented fume hood, checked for removable contamination, and then stored in the fume hood until the time of use. From a radiation safety perspective, the use of capsules presents less chance of contamination during dose administration. Even if the patient were to vomit shortly after swallowing, the double encapsulated gelatin capsule(s) would likely be intact. A local nuclear pharmacist (*Tom Gentle, RPh, BCNP, oral communication, December 2000*) provided an estimate of 10–15 min for a capsule to completely dissolve, especially when the radionuclide is double encapsulated. Compared with the use of a liquid, capsules likely also reduce radiation dose to the esophagus.

If the dose is administered in liquid form, even greater care must be exercised. Plastic-lined absorbent pads should

cover the dosing table and those areas of the patient's body that would be subjected to any potential spillage. The dose must remain in its shielded container during administration. A straw should be provided for the patient to drink the radionuclide contents, and the dose vial should be rinsed at least twice using cold tap water. At the conclusion of dose administration, the technologist can wrap the shielded dose vial, straw, and any other possibly contaminated items in the absorbent pads and remove them from the room. The dose vial will need to be assayed promptly to determine the residual activity so that the actual administered activity may be calculated. (Note: It is important to remember to check the dose vial for external contamination before determination of residual activity to prevent possible contamination of the dose calibrator.) This determination of administered activity can be used in conjunction with daily exposure rate measurements to determine the activity remaining in the patient's body. This is particularly important if the institution still uses the 1110 MBq (30 mCi) criteria for patient release, as is the case in many agreement states. A sample calculation to determine activity remaining in the patient based on exposure rates is illustrated in Table 2.

The door to the therapy room must be adequately posted with a "Caution—Radioactive Materials" sign (*4*) that can be easily removed at the conclusion of the therapy. Unless the isolation room is located on a designated radiation ward, it is recommended that the radiation warning sign be relatively inconspicuous, except to those entering the isolation room, in an effort to reduce the chance of alarming other patients on the ward. Instructions and precautions for nursing staff should also be posted on the isolation room door and in the patient's chart.

**TABLE 2**
Determination of Activity Remaining in a Patient's Body Based on Exposure Rate Measurements

***Sample Calculation:***

An $^{131}$I therapy patient is administered a therapy dose of 7400 MBq (200 mCi). An initial exposure rate reading is made a distance from the patient soon after dosing and is determined to be 50 $\mu$Gy/h (5 mR/h). The dosing vial is assayed after the dose is administered and is found to contain 29.6 MBq (800 $\mu$Ci) of residual activity. Approximately 24 h later, a second exposure rate reading of 22 $\mu$Gy/h (2.2 mR/h) is obtained at the same distance from the patient as on the previous day. Based on the dose rate measurements provided, what activity remains in the patient's body 24 h after dose administration?

***Solution:***

$$\text{Activity actually administered} = (7400 - 29.6)\text{MBq}$$
$$= 7370.4\ \text{MBq (199.2 mCi)}$$

Since exposure rate is directly proportional to the activity, the following proportion can be established:

$$\frac{\text{Initial Exposure Rate}}{\text{Administered Activity}} = \frac{\text{New Exposure Rate}}{\text{Remaining Activity}}$$

$$\frac{50\ \mu\text{Gy/h}}{7370.4\ \text{MBq}} = \frac{22\ \mu\text{Gy/h}}{x}$$

$$50x = (22)(7370.4)$$

$$x = 3243\ \text{MBq (87.6 mCi)}$$

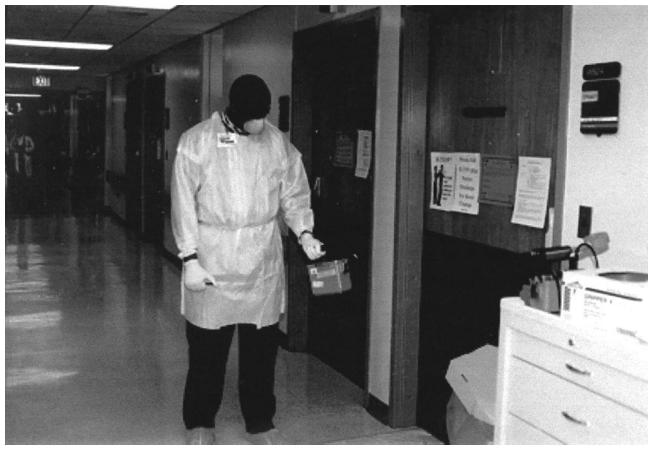

**FIGURE 1.** Exposure rate surveys are conducted in the hallway outside the isolation room to ensure regulatory compliance.

## AREA SURVEYS

Patient exposure rate measurements, obtained using an ionization chamber, should be made immediately after dosing and thereafter on a daily basis during the period of isolation. These measurements may be made with the patient sitting at the head of the bed and from the same location in the room each day. Bed linens should be changed by the patient or the nursing staff just before exposure readings are made. This can be done in an effort to reduce background radiation levels in the room. In addition, daily area surveys of hallways, stairwells, and rooms adjacent to the isolation room, shown in Figure 1, must be conducted and documented to ensure that the dose to any individual in these unrestricted areas does not exceed 20 $\mu$Sv (2 mrem) in 1 h and 1 mSv/yr (100 mrem/y) (*4*,*8*). Daily surveys are required because exposure rates will decrease with time as a result of biological elimination and radioactive decay. These exposure rates will drop even faster if the patient is encouraged to remain well hydrated during the therapy.

Daily wipe tests (Fig. 2) should also be conducted in the hallway just outside the isolation room and at the nurses' station. If contamination is detected in either of these areas, it is most likely indicative of noncompliance with rules originally established to minimize contamination spread. Should this occur, the contaminated areas should be cleaned to background levels and the rules reemphasized.

Although it is common for the isolation period to last for only 2–3 d, contaminated food trays and linens should be removed from the room each day by nuclear medicine or radiation safety personnel to reduce background radiation levels in the room. These items should be stored and allowed to decay to background levels before disposal. Linens can be returned to the laundry for reuse after a 90-d storage period. All items must be surveyed with a GM detector before disposal or reuse to ensure no detectable radiation. Decay-in-storage records must be kept for 3 y (*9*).

**FIGURE 2.** Wipe tests are conducted daily in the hallway and at the nurses' station to ensure contamination control.

## PATIENT RELEASE FROM THE MEDICAL FACILITY

The revision of federal criteria for release of patients containing therapeutic levels of radionuclides as described in *Regulatory Guide 8.39* is still an issue of concern to regulatory officials in several agreement states. As a result, many agreement state facilities continue to use the older release criteria. These criteria state that the patient may be released from the licensee's control either when activity levels within the patient drop below 1110 MBq (30 mCi), or dose rates at 1 meter from the patient drop below 50 $\mu$Sv/h (5 mrem/h). (Note: Regulatory Guide 8.39 recommends 1221 MBq (33 mCi), or a dose rate at 1 m of less than 70 $\mu$Sv/h (7 mrem/h) for $^{131}$I). When either criteria is met, the patient may be released to return home.

On the day of release from isolation, the patient may change back into his or her own personal clothing, leaving the contaminated scrubs in the room to be handled in the same manner as contaminated linens. Before exiting the room, shoe covers should be provided to prevent any possible tracking of contamination from the room.

Federal regulations (*5*) require the patient to be provided with methods to reduce radiation exposure to others if there exists the possibility that an individual might receive a dose in excess of 1 mSv (100 mrem) based on exposure rate readings upon leaving isolation. If the institution has not developed its own set of patient instructions, a commercially available pamphlet entitled *Guidelines for Patients Receiving Radioiodine Treatment* (*10*) is available. In the case of a nursing mother, if the dose to the child is likely to exceed 1 mSv (100 mrem), specific instructions must be provided regarding interrupting or discontinuing breastfeeding. These instructions must also include the consequences of failure to follow the recommendations. If the dose could exceed 5 mSv (500 mrem), records of the instructions provided must be maintained for 3 y after patient release.

### Room Decontamination and Waste Disposal

Once the patient has been released from isolation and has vacated the room, the radiation isolation room must be decontaminated before being used by other patients (*4*). Contaminated articles remaining in the room either must be decontaminated to background levels or disposed of as radioactive waste. Only experienced radiation safety or nuclear medicine personnel should conduct room decontamination procedures. Special attention should be given to the following:

*Linens.* All patient linens and towels should be stored for at least 10 physical half-lives (approximately 90 d for $^{131}$I), then surveyed with a G-M detector. If no activity is detected, these items may be laundered and returned to service.

*Telephone, nurse call devices, TV remote controls.* If these items were adequately covered with protective plastic covering initially, there should be minimal contamination. The covering should be removed, and each item checked with a wipe test to verify that contamination did not occur.

*Disposable personal items, eating utensils, and food trays.* Any disposable personal items (e.g., toothbrush, toothpaste, mouthwash, combs, food trays, magazines) should be disposed of as radioactive waste. These items can be stored for 90 d, surveyed to ensure that background levels have been attained, and then disposed of as regular waste.

*Room floors, door handles, and guard rails.* Protective coverings should be removed and each of these items checked with a wipe test.

If contamination is found, the area must be cleaned (*4*) to background levels (less than 200 dpm per 100 square centimeters).

*Bathroom facilities.* Because contamination will most likely be found in this area, great care should be exercised. All protective coverings must be removed, and all areas surveyed with a G-M detector and wipes. All bathroom surfaces should be cleaned to background levels. The additional precautions taken initially should reduce the extent of contamination that would normally be found here.

Results of the final overall room survey should be recorded on a room survey form and maintained for 3 y. Housekeeping may enter the room for general cleaning only after decontamination procedures are completed.

Personnel dosimeters assigned to members of the attending nursing staff should be collected and processed at an appropriate time. Thyroid bioassays of attending staff should be conducted and the results documented, preferably within 24 h but no later than 3 d after the therapy has concluded (*4*).

## SOURCES OF ASSISTANCE

The author strongly encourages technologists working in an agreement state facility to become familiar with their state regulations regarding patients receiving radionuclide therapy. Many states have their regulations readily accessible online. Such regulations may be equivalent to, or more stringent than, federal regulations. For those technologists working either in a federal facility or a nonagreement state, refer directly to regulations found in 10 CFR 20 and 10 CFR

35. Regulations are constantly subject to change, and the technologist must be aware of these changes when they occur.

In addition to the regulations, the author recommends NCRP Report #37, *Precautions in the Management of Patients Containing Therapeutic Amounts of Radionuclides* (*11*), and a publication entitled *The Nuclear Medicine Handbook for Achieving Compliance with NRC Regulations* (*12*). Both publications provide numerous useful recommendations, sample forms, and instructions for patients and staff.

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