Radioprotection Using Iodine-131 for Thyroid Cancer and Hyperthyroidism:
A Review

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Radioiodine (iodine-131, or I-131) therapy has been used successfully for thyroid therapy for more than 50 years. Protocols for treatment with I-131 differ from country to country and even from hospital to hospital in the same country. Daily area surveys of hallways, stairwells, and rooms adjacent to isolation rooms must be conducted and documented to ensure that doses to any individuals in unrestricted areas do not exceed 20 mcSv (2 mrem) in one hour. Nursing and housekeeping staffs must realize that once therapy has begun, no items are to be removed from the room unless first cleared by nuclear medicine or radiation safety personnel. With proper education and instructions for patients and their family members, radiation exposure to healthcare professionals and the general public can be minimized. The objectives of this article are to review (a) practical radiation safety concerns associated with hospitalized patients receiving I-131 therapy, (b) preventive measures to minimize potential exposure and contamination problems, and (c) radiation safety precautions and preventive measures to minimize radiation exposure to family members and helpers living with patients receiving outpatient I-131 therapy.

Radioiodine (iodine-131, or I-131) therapy is one of three major strategies for the treatment of papillary or follicular thyroid cancer and hyperthyroidism, used successfully for more than 50 years. For hyperthyroidism, the other two methods are surgery and treatment with antithyroid drugs. I-131 is usually the method of choice because the benefits far outweigh the risks, it is relatively inexpensive, it is easily tolerated by patients, and, except for occasional hypothyroidism, the therapy is almost without side effects (Shapiro, 1993). Regardless of the aim of treatment, the best strategy from a protection point of view is to use as small an amount of radioactivity as possible to get the desired effects and benefits for patients (International Commission on Radiological Protection [ICRP], 1991). This is in accordance with the ALARA principle (all exposure shall be kept *a*s *l*ow *a*s *r*easonably *a*chievable), which is recommended by the ICRP (1977). The use of radiation is restricted and controlled. The council of the European Union, in a directive on health protection of individuals from dangers of ionizing radiation in relation to medical exposures (European Communities, 1997), stated that "for all medical exposure of individuals for radiotherapeutic purposes, exposures of target volumes shall be individually planned; taking into account that doses of non-target volumes and tissues shall be as low as reasonably achievable and consistent with the intended radiotherapeutic purpose of the exposure." The directive has been implemented into the legislation of each member country (Swedish Radiation Protection Authority, 2000). The Office of Nuclear Regulatory Research (ONRR) regulates I-131 in the United States.

At a Glance

✦ Practical radiation safety concerns are associated with hospitalized patients receiving radioiodine therapy.

✦ Preventive measures can be taken to minimize potential exposure and contamination problems.

✦ Nurses should learn radiation safety precautions and preventive measures to minimize radiation exposure to family members and helpers living with outpatients receiving radioiodine therapy and the general public.

The first report of radioiodine therapy for metastatic thyroid carcinoma was in 1945 (Seilini & Marinelli). The efficacy of radioiodine therapy is directly related to tumor uptake and retention. Effective tumor uptake is achieved with a concentration of 0.5% of the dose per gram of tumor tissue with an effective

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half-life of at least four days. The radiation-absorbed dose delivered to thyroid tissue is related to the activity administered and the fraction of the dose that is taken up by the thyroid tissue. In such a situation, administration of 5.55 GBq (150 mCi) I-131 would deliver a tumor dose of approximately 25,000 rad (Maxon et al., 1983). Figure 1 provides definitions of radiation dose abbreviations.

The term "ablation" is generally used to describe destruction of residual functioning thyroid tissue in the neck. Ablation after initial surgery decreases the risk of recurrence and death from well-differentiated thyroid cancers (Hurley & Becker, 1988; Varma, Beierwaltes, Nofal, Nishiyama, & Copp, 1970). Ablation has been achieved with one or more doses of 925–1,110 MBq (25–30 mCi) I-131 (Leung, Law, & Ho, 1992; McCowen, Adler, Ghaed, Verdon, & Hofeldt, 1976). I-131 ablation following total thyroidectomy is considered an indispensable element of successful treatment of differentiated thyroid carcinoma (Alevizaki et al., 2006).

When considering radiation safety precautions for attending personnel, members of the general public, and patients in adjacent rooms, remember that I-131 emits negative ß particles (maximum energy approximately 807 keV) and a prominent 364-keV gamma photon. The ß delivers the major portion of the radiation dose to the remnant thyroid tissue, and the penetrating gamma poses a potential radiation hazard to others outside a patient's room. In addition to personnel irradiation, external and internal contamination is potentially hazardous to people entering a patient's room after dose administration. Once a patient is given I-131 orally, regulations may require a short period of isolation in the medical facility, typically two or three days, until radiation exposure rates drop to acceptable levels. That time is when the greatest potential exists for contamination and radiation exposure problems (Thompson, 2001).

Documented radiation safety instruction is required for attending personnel (ONRR, 2000a). Topics covered must include patient control, visitor control, proper techniques for entering and exiting a 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, whom to contact in the event of a medical emergency involving a treated patient, and radioactive waste control. In addition to periodic training sessions for attending staff, videotapes and safety manuals should be made available and left at the nurses' station for reference.

The objectives of this article are to review (a) practical radiation safety concerns associated with hospitalized patients receiving I-131 therapy, (b) preventive measures to minimize potential exposure and contamination problems, and (c) radiation safety precautions and preventive measures to minimize radiation exposure to family members or helpers living with patients receiving outpatient I-131 therapy.

Ci: Curie, the former unit for radioactivity

GBq: Gega Bequerel. Bequerel is the S.I unit of the radioactivity.

Gy: gray = 100 rad. Gy is the S.I unit for the radiation absorbed dose.

Rad: radiation absorbed dose

Figure 1. Radiation Dose Abbreviations

General Initial Procedures

Radiation safety instruction for patients and 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, avoidance of contamination of personal items, ways to assist the nursing staff, instructions for visitors (if allowed), and ways to reduce radiation exposure to family members when the patient returns home.

Pregnant members of the nursing staff and those trying to conceive should not attend to patients receiving I-131 therapy. The possibility of internal contamination with I-131 is especially hazardous for such individuals because it can cross the placental barrier and destroy the fetal thyroid in addition to providing excessive radiation doses to the fetus. Once the attending staff has been trained in radiation protection, the same individuals should be used for future therapies.

Room selection and preparation also are 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. The room must have its own private bathroom facilities.

Regardless of which of the methods are used, particular care must be taken in the preparation of bathroom facilities, the site of greatest contamination. The bathroom floor should be covered completely in bench paper, an absorbent material, or thicker absorbent bench pads. The toilet seat and sink handles should be covered with plastic. Relatively high levels of contamination also will exist in the sink and drains. If greater care is taken initially to prepare the bathroom of an isolation room, less time will be required in its decontamination to Nuclear Regulatory Commission regulatory limits of less than 200 disintegration per minute per 100 cm² for release of the room for use by other patients (ONRR, 2000a).

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 instructed before patient dosing that personal protective equipment (disposable surgical gown, two pairs of gloves and shoe covers, and a surgical mask) must be worn when entering a patient's room. Each item must be removed properly upon exiting and stored in a designated location for pick-up by nuclear medicine or radiation safety personnel.

Because of the high potential for contamination spread, no visitors should be allowed in the room once therapy has begun. Visitor policy may vary from one institution to another, but a "no visitor" policy is strongly recommended by Thompson (2001) as a means of implementing the ALARA concept. If visitation is allowed, restrict it to immediate family members older than 18 years who are not pregnant or possibly pregnant. A visitor's chair can 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 ensure that,

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

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. Background levels are monitored and measured by radiation protection officers. The worldwide average background dose for a human being is about 2.4 millisievert per year (United Nations Scientific Committee on the Effects of Atomic Radiation, n.d.). Reusable items should be stored for approximately 90 days and surveyed with a G-M detector to ensure no detectable radiation before their release for disposal. Nursing and housekeeping staff must be informed that, once therapy has begun, no items may be removed from the room unless first cleared by nuclear medicine or radiation safety personnel.

Preparation of Hospitalized Patients

Because of the contamination problems associated with I-131 therapy, patients should receive scrubs to wear for the period of isolation. Personal clothing should not be allowed until the day of release from isolation. This minimizes the possibility of contaminated clothing being taken home by the patient, thereby reducing radiation exposure to family members. Disposable personal grooming items (e.g., toothbrush, comb, hairbrush, razor) also are recommended. Books, magazines, and any other items in the room after dose administration should be disposed as radioactive waste or stored and allowed to decay for at least 90 days at the conclusion of the isolation period (Thompson, 2001).

Good practice includes inquiring about the patient's current state of health before dosing. If a patient is coughing or sneezing, this could lead to an increased chance of contamination of personnel and room contents, likely requiring more extensive room preparation. An incontinent patient presents major contamination problems unless catheterized. In addition, a catheter bag must be shielded adequately to reduce exposure to attending personnel. A makeshift shield can be constructed with plastic or acrylic as the inner lining wall and at least a 5 mm thick lead outer wall. The plastic minimizes bremsstrahlung production (bremsstrahlung radiation is a type of x-ray that is produced by the interaction of electrons or β particles with the nuclei of high-atomic-number elements such as lead) because it has a low effective atomic number. The plastic attenuates β particles, and lead attenuates gamma photons that are emitted from I-131 (Thompson, 2001).

If blood or urine specimens are to be collected, collection should occur before a 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 labeled clearly as radioactive. After a patient's release from isolation, specimen collection may continue without special precautions.

All female patients of childbearing age must take 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 no I-131 remains in the milk. Radiation doses delivered to an infant or developing fetus as a result of this type of therapy can be devastating. Therefore, the consequences of not following precautions must be emphasized strongly to patients, both orally and in print (ONRR, 2000b). If a patient is a nursing mother, the mother should pump enough breast milk before 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 (Jonsson & Mattsson, 2004; ONRR, 2000b).

Because most patients are somewhat apprehensive about being exposed to radiation, special attention to patient education can be very helpful in allaying fears and obtaining a higher degree of patient cooperation during therapy. Most patients 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 (Thompson, 2001).

## Management of Outpatients Receiving High-Dose Iodine-131

Patients should be instructed to limit time spent in public places the first few days and to avoid places such as theaters, sport arenas, and stadiums, where the option of getting a seat farther away from others may not always be possible (Parthasarathy & Crawford, 2002). If children must reside in the patient's residence, a private bedroom and bathroom for use by the patient are recommended. If the home is small and crowded, such that no facilities are available to limit the absorbed dose to less than 5 mSv (500 mrem) in a year to an adult family member living with the patient, then the patient should be treated with high-dose I-131 as an inpatient.

Dose Administration

Most nuclear physicians prefer fixed-dose I-131 therapy without actually calculating the dosimetry for ablation. The treatment dose variances among different centers are wide, with a range of 0.925–7.4 GBq (25–200 mCi) (Pant, Sharma, Bal, Kumar, & Rath, 2006), depending on whether it is given for residual functioning thyroid tissue in the neck or for metastases detected locally in the neck or in various organs (see Figure 2), as well as the age and gender of a patient. First doses as high as 11.1 GBq (300 mCi) have been given in some centers on the basis of the assumption that metastases may lose their ability to concentrate iodine (Leeper, 1982). Various effective and practical dosing schedules are available for primary thyroid cancer and metastatic diseases (Beierwaltes, 1987; Leung et al., 1992; McCowen et al., 1976).

With high-dose therapy, the dose to the blood should be less than 200 rad to reduce bone marrow toxicity. The total whole-body retained dose at 48 hours should be less than 4.44 GBq (120 mCi) in widespread metastatic thyroid carcinoma and 2.96 GBq (80 mCi) in the presence of lung metastases (Bushnell, Boles, Kaufman, Wadas, & Barnes, 1992; Leeper, 1982). The latter is a precaution to avoid inducing pulmonary fibrosis.

At the designated time, the dose to be administered is brought on a cart to the patient's room in its shielded shipping container. All contamination precautions must be observed. Two pairs of
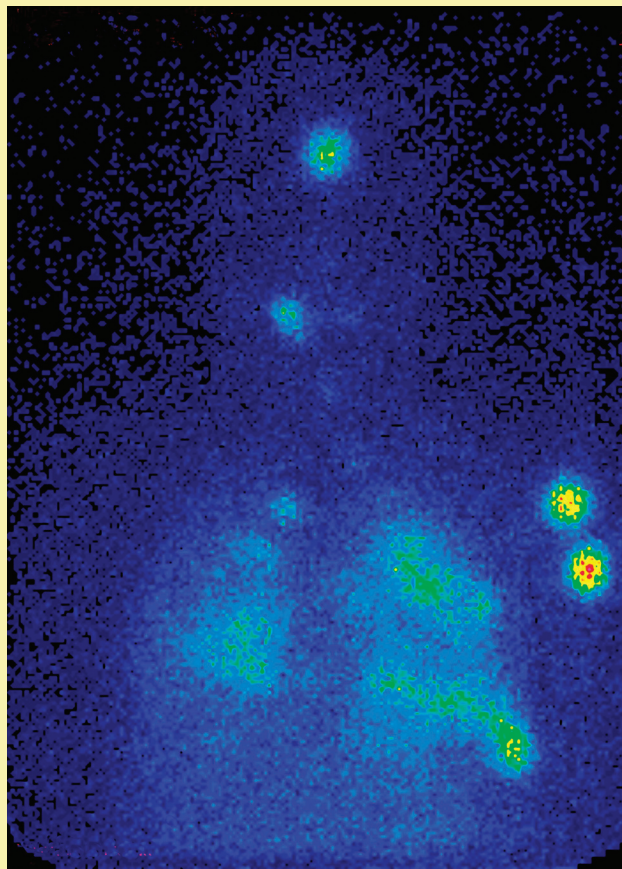
Note. The left humeral head and upper end of the humeral diaphysis (shaft), and the brain. Metastases are shown by the uptake of iodine-131; the focus of uptake located at the level of the mouth corresponds to a salivary stasis in a decayed tooth.

Figure 2. Scintigram With Iodine-131, Anterior View of Metastases of Thyroid Adenocarcinoma of the Lungs

shoe covers, two pairs of gloves, a surgical gown, a mask, and an 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 (Thompson, 2001). If liquid I-131 is to be used for therapy, appropriate use of a closed-circuit liquid delivery system may limit or eliminate, even in the absence of a fume hood, contamination of the ambient air and skin and the possibility of any accidental spillage (Parthasarathy & Crawford, 2002). Studies have shown that absorbent materials used in the packaging of I-131 capsules can be sources of I-131 contamination (Hackett, Perdikaris, & Ruffin, 1995). As with any volatile radionuclide, the capsule container should be opened initially 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. Contrasted with the use of liquid, capsules likely also reduce radiation dose to the esophagus.

If a dose is administered in liquid form, even greater care must be exercised. Plastic-lined absorbent pads should cover the dosing table and areas of the patient's body that could be subjected to 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 with 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 should be assayed promptly to determine the residual activity so that the actual administered activity may be calculated. Remember to check the dose vial for external contamination before determination of residual activity to prevent possible contamination of the dose calibrator. The 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 an institution still uses the 1,110 MBq (30 mCi) criteria for patient release, as is the case in many agreement states. The radiation officer can calculate and inform the staff about current activity levels. The door to the therapy room must be adequately posted with a "Caution—Radioactive Materials" sign (ONRR, 2000a) that can be removed easily at the conclusion of therapy. Instructions and precautions for nursing staff also should be posted on the isolation room door and in the patient's chart.

Area Surveys

Patient exposure rate measurements, obtained in an ionization chamber, should be made immediately after dosing and thereafter on a daily basis during the period of isolation. The 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 to reduce background radiation levels in the room. In addition, daily area surveys of hallways, stairwells, and rooms adjacent to the isolation room must be conducted and documented to ensure that the dose to any individual in such unrestricted areas does not exceed 20 mcSv (2 mrem) in one hour and 1 mSv (100 mrem) per year (ONRR, 2000d). Daily surveys are required because exposure rates decrease with time as a result of biologic elimination and radioactive decay. Exposure rates drop even faster when a patient remains well hydrated during therapy. Daily wipe tests should be conducted in the hallway just outside the isolation room and at the nurses' station. If contamination is detected in either of those areas, it is most likely indicative of noncompliance with rules originally established to minimize contamination spread. The contaminated areas should be cleaned to background levels, and the rules should be reemphasized.

Although the isolation period usually lasts only two or three days, 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. Such 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-day storage period. All items must be surveyed with a G-M detector before disposal or reuse to ensure no detectable radiation. Decay-in-storage records must be kept for three years (ONRR, 2000c).

Patient Release From the Medical Facility

A patient may be released either when activity levels in the patient drop below 1,110 MBq (30 mCi) or when dose rates at 1 m from the patient drop below 50 mcSv (5 mrem) per hour. (The ONRR [1997] recommends 1,221 MBq (33 mCi) or a dose rate at 1 m of less than 70 mcSv per hour [7 mrem per hour] for I-131). When either criterion 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, the patient should remove shoe covers to prevent any possible tracking of contamination from the room.

Federal regulations (ONRR, 2000b) require that patients receive education about methods to reduce radiation exposure to others, if the possibility exists that an individual might receive a dose in excess of 1 mSv (100 mrem) based on exposure rate readings upon leaving isolation. If an institution has not developed its own set of patient instructions, a commercially available pamphlet titled, "Guidelines for Patients Receiving Radioiodine Treatment" (Reston, 1997) is available from the American Society of Nuclear Medicine. As mentioned earlier, 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. The instructions also must include the consequences of failure to follow the recommendations. When a dose exceeds 5 mSv (500 mrem), records of instructions provided must be maintained for three years after patient release. 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 hours but no later than three days after therapy has concluded (ONRR, 2000a).

Effective half-life for I-131 is five days. In the first 24 hours after dosing, patients receiving the therapy excrete 30%–75% of the administered dose (Phan, Ling, & Wasnich, 1987; Thompson, 2001). Most of it is in the urine, but a significant amount enters the gastrointestinal tract via salivary excretion and gastric secretion. Measurable amounts also are secreted in perspiration. Although details about decreasing radiation contamination and reducing personal exposure have been discussed regarding inpatient treatment with I-131 (Thompson), a few points should be stressed regarding outpatient treatment with high-dose I-131. Patients should be instructed to be careful not to spill any urine and to flush the toilet two or three times after each use. Advise men to urinate while sitting on the toilet to prevent possible contamination outside the toilet. Thompson recommended that any contaminated flushable parts of diaper pads should be flushed down the toilet and the remainder washed in a tub by gloved hands before discarding into the trash. Parthasarathy and Crawford (2002) recommended that female patients with urinary incontinence limited to only minor dribbling use a half-inch (1.27 cm) stack of facial tissues, as needed, and that the soiled stack of tissues be flushed down the toilet. The thickness of a tissue stack can be increased to an inch (2.54 cm) or so depending on the degree of incontinence and the patient's convenience. Male patients with urinary incontinence should be advised to use a condom catheter with a urine collection bag, which should be emptied as frequently as is practical.

Patients should be advised to wear only machine-washable clothing during the first week of therapy because a measurable amount of radioactivity is secreted in perspiration, so soiled clothes should be washed separately. If a patient has been caring for an infant before treatment, he or she should be instructed to avoid any close contact with the infant for several days after treatment. If contact is unavoidable, then the utmost care should be taken to keep contact to a minimum. If other members live in the household, continuous close contact or proximity should be avoided. Any time spent with an individual should be short, and a distance of more than 1 m should be maintained (Thompson, 2001).

Iodine ablation therapy for patients with thyroid cancer who are receiving dialysis poses unique radiation safety challenges. Exposure to gamma- and β-negative particles by the hemodialysis (HD) staff is a concern that has not been well studied. Modarresifar, Almodovar, Bass, and Ojha (2007) developed and implemented radiation safety measures to give patients optimal treatment doses, reduce radiation to patients (critical organs and whole body), and protect HD personnel. The strategies included placing two lead shields between a patient and an HD nurse, and having two alternating nurses monitor HD to reduce their radiation exposure.

Measurable amounts of I-131 are excreted in the feces. In fact, on total-body scans, a relatively intense distribution generally is seen throughout the large colon on the second and the third days, more so on the third day. Therefore, a laxative taken on the second or at least the third night will stimulate faster elimination of feces containing I-131 and reduce the radiation-absorbed dose to the abdominal organs, the thoracolumbosacral spine, and the pelvis (Culver, Dworkin, & Forsaith, 1993). During the first weeks of therapy, if patients treated with I-131 need to seek other medical evaluation or treatment for any reason, they should be instructed to inform medical personnel of the treatment they have received.

Because a significant amount of dose is excreted in the saliva, any facial tissues that are used in the first few days should be flushed down the toilet, not disposed of in normal trash. Patients should be instructed to avoid foods that can become contaminated with saliva during eating and have residue that needs to be discarded (e.g., chicken wings, ribs, fruits with a core). Fruits, such as apples, can be consumed after they are cut into pieces and the core discarded. Fruits with a core can be disposed of in public sewage with the use of a garbage disposal. Deboned chicken can be eaten without concern of contaminating household trash. Foods such as chicken wings eaten during the first few days after treatment with I-131 can result in bones contaminated from the patient's saliva. Discarding them in trash that is picked up by a public garbage truck may result in the truck being impounded at the entrance to a landfill, depending on how stringent local regulations are (Culver et al., 1993).

To avoid contaminated disposable utensils going into normal trash, patients should use personal plates, glassware, and silverware exclusively. They are to be cleaned by the patient (or a helper with gloved hands) in a private bathroom sink and kept in the patient's room for daily use for one week. Alternatively, a dishwasher can be used safely to clean plates and utensils without cross-contamination.

Side Effects and Complications

Significant side effects are rare with doses around 3.7 GBq (100 mCi). However, dose-related side effects including nausea, vomiting, gastritis, loss of taste, radiation cystitis, conjunctivitis, keratoconjunctivitis, and decreased testicular function have been reported (Alexander, Bader, Schaefer, Finke, & Kirsch, 1998; Solans et al., 2001; Van Nostrand, Neutze, & Atkins, 1986). The oral use of lemon drops in the first few days may help decrease the incidence and severity of radiation syndromes and absorbed radiation dose to the salivary glands (Parthasarathy & Crawford, 2002). An extremely minimal increased risk of leukemia and bladder, breast, and salivary carcinomas has been noticed when cumulative dosage exceeds 37 GBq (1.0 Ci) in less than one year (Alexander et al.; Bushnell et al., 1992; Dottorini, Lomuscio, Mazzucchelli, Vignati, & Colombo, 1995; Van Nostrand et al.).

Discussion

Protocols for treatment of thyroid cancer and hyperthyroidism with I-131 differ from country to country and even from hospital to hospital in the same country. The most successful protocol is to determine the thyroid mass and the more detailed biokinetics (individual uptake and half-life) of I-131 in the individual's thyroid, thus enabling a more precise absorbed-dose calculation. Because that method requires several visits by the patient to the hospital before treatment, it is time consuming (Clerc et al., 1993; De Bruin, Croon, de Klerk, & van Isselt, 1994). The volume of the thyroid is determined using palpation, gamma camera scintigraphy, and/or ultrasound imaging. Corrections can be made to the absorbed-dose rate if thyroid volume changes during therapy (Di Martino, Traino, Brill, Stabin, & Lazzer, 2002; Traino, Di Martino, Lazzeri, & Stabin, 2000). Most of the time, however, the effect is disregarded and the volume of the thyroid is assumed to be unchanged through the entire period of therapy.

If the thyroid does not receive enough I-131, the cancerous cells will not be killed. The 24-hour uptake is the most common uptake measurement, and it is convenient and widely used (Shapiro, 1993). The effective half-life depends on the physical and biologic half-life and varies among patients (Bajnok et al., 1999; Berg, Michanek, Holmberg, & Fink, 1996). The absorbed dose is proportional to the effective half-life, and the absorbed dose also will vary. For patients in whom the effective half-life is shorter than assumed in a protocol, therapy could result in undertreatment and the need for a second treatment. If a patient has an effective half-life longer than assumed, the patient will receive a higher absorbed dose than planned and be exposed to unnecessary radiation.

As reported in Peters, Fischer, Bogner, Reiners, and Schleusener (1995), the results from treatment with a fixed dose were very effective in patients with a small thyroid volume but not in patients with a larger thyroid volume. This is not strange because the results of therapy depend on the absorbed dose to the thyroid, and a small thyroid volume will receive a higher absorbed dose than a larger volume, if administered the same amount of activity. For I-131 therapy, the sensitivity differs between diagnosis and also might differ among different geographical regions and levels of iodine supply. Some authors claim that if all patients were to be cured, an absorbed dose of 200–300 Gy to the thyroid would be necessary (Reinhardt et al., 2002; Willemsen, Knesewitsch, Kreisig, Pickhardt, & Kirsch, 1993); other authors claim that a mean absorbed dose of 30 Gy might be enough in some patients (Rajashekharrao & Nair, 1991). This would be an overtreatment for patients who need less than 100 Gy to become hypothyroid.

The critical area for I-131 therapy employed in patients with thyroid cancer, either for ablation of the postsurgical residue or for recurrent or metastatic disease, is the bone marrow (Traino, Di Martino, Boni, Mariani, & Lazzeri, 2004). In the absence of specific measurements of radioactivity uptake in the bone marrow, estimation of bone marrow dosimetry in patients undergoing I-131 therapy is based on the measurement of activity in the blood (Sgouros, 1993; Siegel et al., 1990). In that regard, the committed dose to blood should not exceed 2–3 Gy (Maxon, Thomas, & Samaratunga, 1997). With high-dose therapy, the dose to the blood should be less than 200 rad to reduce bone marrow toxicity. The total whole-body retained dose at 48 hours should be less than 4.44 GBq (120 mCi) in widespread metastatic thyroid carcinoma and 2.96 GBq (80 mCi) in the presence of lung metastases (Bushnell et al., 1992; Leeper, 1982); the latter is a precaution to avoid pulmonary fibrosis.

Conclusions and Recommendations

The choice of treatment for thyroid cancer and hyperthyroidism is likely to be influenced by different factors, such as cost, convenience, subjective biases including local traditions, and patient preferences. The result obtained by Jonsson and Mattsson (2004) showed that the protocol for calculating the administered activity in I-131 therapy is not optimized in all hospitals. An optimized method gives a radiation dose to the patient that is enough for the intended therapeutic result, while the radiation absorbed dose to nontarget tissue is as small as reasonably achievable.

I-131 is an effective treatment for thyroid cancer and hyperthyroidism. To reduce exposure to patients, staff, family members, and others, healthcare professionals must follow precautions. With proper education and instructions, radiation exposure to patients, families, and the general public can be minimized easily (Parthasarathy & Crawford, 2002). For patients, being treated as outpatients has social benefits. If recommended guidelines for releasing patients are followed, and if patients' living conditions are assessed adequately, outpatient treatment with high-dose I-131 is safe, is cost effective, and improves patient satisfaction (Panzegrau, Gordon, & Goudy, 2005).

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