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Radiation Safety Guidelines for Radioimmunotherapy With Yttrium 90 Ibritumomab Tiuxetan

Carolyn Hendrix, RN, OCN®

In 2003, approximately 53,400 people in the United States were diagnosed with non-Hodgkin's lymphoma (NHL), making it the sixth most common cancer in the United States (American Cancer Society, 2003). Unlike most other malignancies, the incidence and mortality of NHL are increasing (McKean-Cowdin, Feigelson, Ross, Pike, & Henderson, 2000). Conventional cancer therapies such as chemotherapy and external beam radiation have not proved successful in curing most forms of indolent, low-grade, or follicular forms of NHL. Furthermore, these conventional therapies often are associated with significant toxic effects in patients.

Disseminated disease typically has been treated with chemotherapy, external beam radiotherapy, immunotherapy, or a combination of these three modalities. Chemotherapy has limited efficacy and, often, burdensome toxicity. External beam radiation is not tumor specific, and it delivers the same amount of radiation to healthy organs as it does to tumor sites, thereby limiting the dose of radiation that can be given. Recent advances in radiation therapy, such as those used with conformal radiation and intensity-modulated radiation therapy technology, target tumors with a higher dose of radiation while delivering less radiation exposure to adjacent tissue. However, this technology is not yet widely available or necessarily appropriate for treating disorders such as lymphoma.

As the use of radioimmunotherapy (RIT) becomes more widespread, nursing staff outside traditional radiation oncology or

Radioimmunotherapy is a new cancer therapy that combines the cytotoxicity of radiation with the tumor-specific targeting of monoclonal antibodies. Yttrium 90 (Y-90) ibritumomab tiuxetan (Zevalin™, IDEC Pharmaceuticals Corporation, San Diego, CA) is indicated for the treatment of patients with relapsed or refractory low-grade, follicular, or transformed B-cell non-Hodgkin's lymphoma (NHL), including patients with rituximab-refractory follicular NHL. Y-90 ibritumomab tiuxetan requires only universal safety precautions and does not impose undue risks or radiation safety restrictions on patients or healthcare workers. The ibritumomab tiuxetan regimen can be administered safely in an outpatient setting. Nurses should become familiar with the necessary precautions in caring for patients treated with Y-90 ibritumomab tiuxetan, both to educate patients about safety issues and to minimize the risk of radiation exposure to staff and others.

Key Words: radioimmunotherapy, safety

nuclear medicine facilities will need to understand radiation safety issues and practices. Additionally, nursing staff already familiar with conventional radiotherapy treatment modalities will need to become familiar with the new, often less demanding, safety requirements of RIT. This article reviews the basics of radiation safety and discusses the necessary precautions in caring for patients treated with the yttrium 90 (Y-90) ibritumomab tiuxetan RIT regimen (Zevalin™, IDEC Pharmaceuticals Corporation, San Diego, CA).

Radioimmunotherapy

RIT is an approved treatment modality that combines the cytotoxicity of radiation with the specificity of monoclonal antibod-

ies for tumor cell surface antigens (Potamianos, Varvarigou, & Archimandritis, 2000). Non-radiolabeled, or "cold," monoclonal antibody therapy for relapsed indolent NHL has been shown to produce a 48% overall response rate in NHL that has relapsed after treatment with chemotherapy, with the median duration of response of 11.8 months (McLaughlin et al., 1998). Still, the median survival after a diagnosis of follicular NHL remains approximately 8–12 years (Reiser & Diehl, 2002). However, RIT can deliver higher doses of radiation to targeted tumors than to nearby healthy organs (Press et al., 1993; Wiseman et al., 2001). After the delivery of the radionuclide to malignant tissue by the antibody's targeting of the antigen, cancer cells are killed

by a combination of the targeted radiation, the biologic effect of the monoclonal antibody, and the crossfire effect of the radiation on nearby tumor cells to which the antibody did not bind (e.g., because of physical inaccessibility, because the tumor cell did

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not express the antigen being targeted) (Illidge & Johnson, 2000).

Safety Guidelines for Radioimmunotherapy

Radiation safety focuses on three key areas: using appropriate shielding during administration, minimizing exposure time, and maximizing distance from the radiation source. Determining the appropriate material and thickness for shielding depends largely on the type of radiation emitted by the radionuclide. Most oncology nurses are familiar with the radionuclide iodine 131, which typically has been used to treat thyroid disease. Iodine 131 emits gamma radiation, and in most instances, its use requires patient isolation, lead shielding during administration, and strict safety precautions after patient discharge. The ibritumomab tiuxetan regimen, however, uses the radionuclide Y-90, which is a pure beta emitter. Therefore, fewer precautions are necessary when using this agent.

Yttrium 90 Ibritumomab Tiuxetan

Y-90 ibritumomab tiuxetan consists of ibritumomab, a murine monoclonal antibody to the CD20 antigen stably bound to tiuxetan, which chelates the radionuclide Y-90 (see Figure 1). Ibritumomab is the parent of the chimeric monoclonal antibody rituximab. In clinical trials, Y-90 ibritumomab tiuxetan has produced overall response rates of 73%–83% in indolent, low-grade, or follicular NHL (Wiseman et al., 2002; Witzig, Emmanouilides, et al., 2003; Wit-

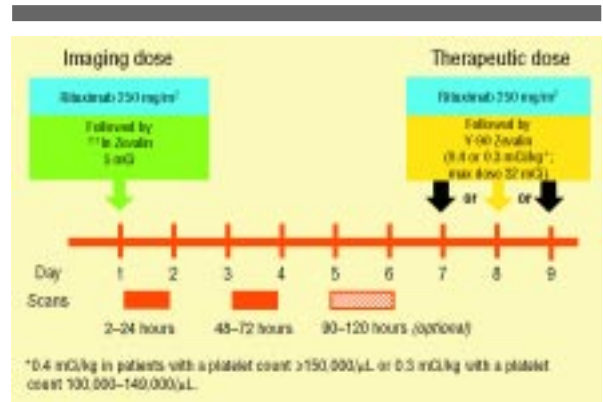
zig, Flinn, et al., 2002; Witzig, Gordon, et al., 2002).

Ibritumomab Tiuxetan Regimen

The ibritumomab tiuxetan regimen is a single-treatment course that is given on two days approximately one week apart (IDEC Pharmaceuticals Corporation, 2002) (see Figure 2). On the first day of the ibritumomab tiuxetan regimen, the patient is given an infusion of rituximab 250 mg/m², followed within four hours by a tracer dose of indium 111 ibritumomab tiuxetan 5 mCi (1.6 mg) injected slowly over 10 minutes. Whole body planar anterior and posterior view gamma images are obtained at 2–24 hours and 48–72 hours after this imaging dose of indium 111 ibritumomab tiuxetan to assess the biodistribution of the tracer dose; an optional third image can be obtained at 90–120 hours to resolve any ambiguities. If the biodistribution is as expected, on regimen days 7, 8, or 9, the therapeutic dose of Y-90 ibritumomab tiuxetan (0.4 mCi/kg if the patient's platelet count is $\geq 150,000/\text{mm}^3$ or 0.3 mCi/kg if the patient's platelet count is 100,000–149,000/mm³) is injected slowly over 10 minutes and again within four hours after the administration of rituximab 250 mg/m². The maximum dose of Y-90 ibritumomab tiuxetan is 32 mCi (IDEC Pharmaceuticals Corporation).

Nurses play a key role in coordinating rituximab infusions given before the imaging and therapeutic doses of radioimmunoconjugate. These rituximab infusions are given to improve the biodistribution of the Y-90 ibritumomab tiuxetan to the tumor sites. The predose of rituximab binds to readily accessible CD20 sites on cells in the peripheral blood and prevents indiscriminate uptake of the radio-labeled antibody in the reticuloendothelial system (Wagner et al., 2002).

Nurses also are integral in providing patient care throughout the regimen of ibritumomab tiuxetan administration. Before treatment is initiated, nursing



¹¹¹In—indium 111; Y-90—yttrium 90

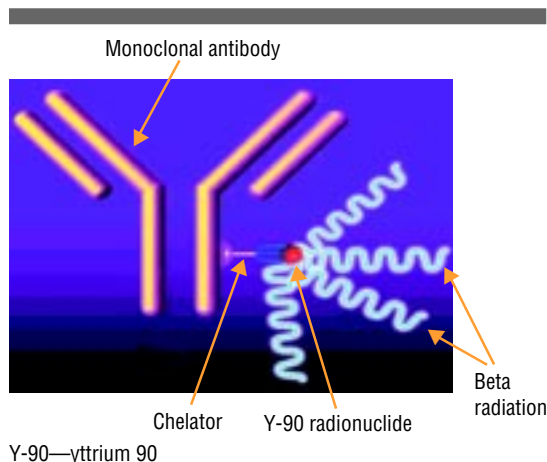
FIGURE 2. IBRITUMOMAB TIUXETAN THERAPEUTIC REGIMEN

Note. Reprinted with permission from IDEC Pharmaceuticals, Inc., San Diego, CA.

staff will be involved in counseling patients, obtaining insurance authorization, and educating patients and their families and caregivers about radiation safety and follow-up care. Coding and reimbursement information, which was revised in 2003, is available online at www.zevalin.com/pdfs/Billing_Guide.pdf. In addition, IDEC Pharmaceuticals Corporation offers a reimbursement assistance program, RESULTS™ for Zevalin, which provides assistance with reimbursement and coding issues as well as programs for the uninsured (800-386-9997, phone; 800-513-8055, fax; www.zevalin.com/html/HealthcareProfessionals/Reimbursement/results.html, Web site).

Safety of Yttrium 90 Ibritumomab Tiuxetan

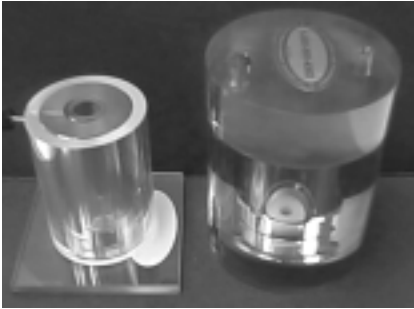
Y-90 emits only beta radiation, which has a mean effective path length of approximately 5 mm in soft tissue (i.e., 90% of the energy is absorbed within a sphere with a radius of 5 mm), and because of this, it does not penetrate outside the patient's body. This form of radiation is absorbed by approximately 1 cm of acrylic; therefore, fewer safety precautions are required in using Y-90 ibritumomab tiuxetan than in using radionuclides such as iodine 131 that emit gamma rays (Wagner et al., 2002). Beta emissions pose minimal radiation hazards to healthcare workers or patients' contacts; as a result, the ibritumomab tiuxetan regimen can be administered on an outpatient basis using only universal precautions for radiation safety. Acrylic shielding is required (acrylic vial and syringe shields are available [see Figure 3]), and patient isolation is unnecessary (see Figure 4). Lead shielding



Y-90—yttrium 90

FIGURE 1. YTTRIUM 90 IBRITUMOMAB TIUXETAN

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- Syringe shield conveniently holds a 12 cc syringe for infusion of yttrium 90 Zevalin™
- Vial shield opens on one end to allow insertion of 10 cc reaction vial; other end opens to allow for drawing out of the vial

FIGURE 3. ACRYLIC SYRINGE AND VIAL SHIELDS

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should not be used in the ibritumomab tiuxetan regimen because of the risk of exacerbating the radiation through the bremsstrahlung effect (i.e., radiation produced by an electronic particle when it is subjected to a sudden stop).

Therapy with Y-90 ibritumomab tiuxetan is generally well tolerated. Most of the non-hematologic side effects that do occur can be attributed to the infusions of rituximab given before radiolabeled ibritumomab tiuxetan; hematologic side effects such as neutropenia and thrombocytopenia most often are predictable, transient, and manageable (Witzig, White, et al., 2003). Oncology nurses should be familiar with the side effects of rituximab and should be prepared to counsel patients about potential side effects; in addition, nurses should be able to

For three days after treatment

- Clean spilled urine and dispose of material contaminated with body fluid (i.e., flush down a toilet or place in a plastic bag in household trash) so that others will not inadvertently handle it.
- Wash hands thoroughly after using a toilet.

For one week after treatment

- Use condoms for sexual relations.

For one year after treatment

- Avoid pregnancy.

If breastfeeding, discontinue and replace with formula. (Duration has yet to be determined; the potential for Zevalin exposure in infants is unknown.)

FIGURE 4. YTTRIUM 90 IBRITUMOMAB TIUXETAN PATIENT RELEASE INSTRUCTIONS

Note. Based on information from IDEC Pharmaceutical Corporation, 2002; Wagner et al., 2002.

TABLE 1. RADIATION EXPOSURE

LEVEL OF EXPOSURE	AMOUNT OF EXPOSURE
Chest x-ray	~ 20 mrem
Average person in the United States	360 mrem/year
Average hospital radiation worker in the United States	+ 150 mrem/year (510 mrem/year total)
Radiation sickness from single dose	> 100 rem
Immune system, vascular damage	> 300 rem

Note. Based on information from Cohen & Lee, 1979; Gotchy, 1978; Kelsey, 1978.

anticipate and address any side effects that occur.

In Y-90 ibritumomab tiuxetan, the chelator stably binds the radionuclide to the antibody. Urinary excretion, the primary route of elimination, accounts for the elimination of only $7.3\% \pm 3.2\%$ of the administered dose over seven days (Wagner et al., 2002).

For the first three days after treatment, patients should be instructed to clean any spilled urine, properly dispose of any materials contaminated with body fluids, and wash their hands thoroughly after using a toilet. In addition, they should be advised to use condoms for sexual relations for the first week after treatment, to avoid pregnancy for one year, and, if breastfeeding, to discontinue and replace with formula (IDEC Pharmaceuticals Corporation, 2002; Wagner et al., 2002). A study in which patients observed these precautions showed that the family member who had closest contact with the patient had minimal radiation exposure of 3.5 mrem over seven days, which is in the range of everyday background radiation (Wiseman, Leigh, Witzig, Gansen, & White, 2000) (see Table 1).

Implications for Practice

The ibritumomab tiuxetan regimen presents oncology nurses with new opportunities for collaboration and education. Because of regulatory, safety, and administrative requirements, RIT necessitates a multidisciplinary approach among oncology nurses, oncology physicians, nuclear medicine and radiation therapy personnel, radiopharmacists, and radiation safety officers. In this team approach, oncology nurses play a key role in ensuring continuity throughout the treatment and, because they are the members of the team with the most direct and ongoing contact with patients, they are in a unique position to counsel patients, families, and caregivers, as well as educate them about the various aspects of cancer care (Volker, 1992), including the precautions necessary to prevent radiation exposure to others during and after Y-90 ibritumomab tiuxetan treatment.

Because many patients with NHL who are treated with RIT already have been treated with several other therapies, nurses must educate patients about the differences between RIT and traditional cancer therapies.

Most patients who are treated with Y-90 ibritumomab tiuxetan are outpatients. Therefore, the nursing staff at outpatient facilities must be trained in radiation safety. Many nuclear medicine or radiation therapy departments are licensed to administer RIT. Most nursing staff members will not be involved directly in administering the radiolabeled components of the ibritumomab tiuxetan regimen, but they should be familiar with safety guidelines. Nurses typically are responsible for administering infusions of rituximab, and they also may assist with patient care activities such as implanted port access or management of the side effects of monoclonal antibodies.

Nurses continually find themselves on the cutting edge of clinical practice. As modalities move from research to clinical practice, nurses must be familiar with new patient care requirements.

Conclusion

As RIT use increases and other tumors are targeted for treatment, nurses in all treatment settings must have a working knowledge of RIT. Because oncology nurses educate patients and caregivers about treatments and their safety, patients will look to them for reassurance that Y-90 ibritumomab tiuxetan therapy requires few and relatively minor safety precautions.

Author Contact: Carolyn Hendrix, RN, OCN®, can be reached at chendrix@hoaghospital.org.

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Radiation Safety Academy

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Rapid Recap

Radiation Safety Guidelines for Radioimmunotherapy With Yttrium 90 Ibritumomab Tiuxetan

- Radioimmunotherapy, an approved treatment option for certain types of non-Hodgkin's lymphoma, combines the cytotoxic effects of radiation with the tumor-specific targeting of monoclonal antibodies.
- Yttrium 90 (Y-90), the therapeutic radionuclide used with ibritumomab tiuxetan, is a pure beta emitter that poses fewer risks to patients, caregivers, and healthcare staff than conventional radionuclides (e.g., iodine 131), which emit both beta and gamma radiation.
- The ibritumomab tiuxetan regimen is a single-treatment course that is given on two days approximately one week apart.
- Universal safety precautions apply with Y-90 ibritumomab tiuxetan therapy.
- For the first three days after treatment, patients should be instructed to clean any spilled urine, properly dispose of any materials contaminated with body fluids, and wash their hands thoroughly after using a toilet.
- Family members and friends need to be reassured that close contact with the patient is not harmful. Minimal radiation exposure, which is in the range of everyday background radiation, is associated with this treatment.