Breast cancer is the most commonly diagnosed cancer in women in the United States; in 2003, an estimated 211,300 new cases will be diagnosed (Jemal et al., 2003). Early-stage breast cancer (i.e., stage I or II) is treated with lumpectomy followed by breast irradiation (i.e., breast-conserving therapy) or mastectomy. Large randomized clinical trials have shown that mastectomy is an equivalent treatment option to lumpectomy and radiation therapy (Arriagada, Le, Ro-\text{\textit{c}}\text{\textit{c}}} \text{\textit{h}}\text{\textit{a}}\text{\textit{r}}d, \text{\textit{\&}} \text{\textit{C}}\text{\textit{o}}\text{\textit{n}}\text{\textit{t}}\text{\textit{e}}\text{\textit{s}}\text{\textit{o}}\text{\textit{r}}, \text{\textit{1}}\text{\textit{9}}\text{\textit{9}}\text{\textit{6}}; \text{\textit{F}}\text{\textit{i}}\text{\textit{s}}\text{\textit{h}}\text{\textit{e}}\text{\textit{r}}\text{\textit{e}}\text{\textit{r}} \text{\textit{e}}\text{\textit{t}}\text{\textit{a}}\text{\textit{l}}\text{\textit{e}}, \text{\textit{2}}\text{\textit{0}}\text{\textit{0}}\text{\textit{2}}; \text{\textit{J}}\text{\textit{a}}\text{\textit{c}}\text{\textit{b}}\text{\textit{o}}\text{\textit{s}}\text{\textit{o}}\text{\textit{n}} \text{\textit{e}}\text{\textit{t}}\text{\textit{a}}\text{\textit{l}}\text{\textit{e}}, \text{\textit{1}}\text{\textit{9}}\text{\textit{9}}\text{\textit{5}}; \text{\textit{v}}\text{\textit{a}}\text{\textit{n}} \text{\textit{D}}\text{\textit{o}}\text{\textit{ng}}\text{\textit{e}}\text{\textit{n}} \text{\textit{e}}\text{\textit{t}}\text{\textit{e}}\text{\textit{l}}, \text{\textit{2}}\text{\textit{0}}\text{\textit{0}}\text{\textit{0}}; \text{\textit{v}}\text{\textit{e}}\text{\textit{r}}\text{\textit{o}}\text{\textit{n}}\text{\textit{e}}\text{\textit{s}}\text{\textit{o}}\text{\textit{n}} \text{\textit{e}}\text{\textit{t}}\text{\textit{a}}\text{\textit{l}}\text{\textit{e}}, \text{\textit{2}}\text{\textit{0}}\text{\textit{0}}\text{\textit{2}}). Patients also undergo a sentinel lymph node biopsy (SLNB) and/or an axillary lymph node dissection (ALND) to determine the extent of the disease.

Adjuvant systemic treatment may be indicated if patients have unfavorable pathologic features (e.g., a tumor larger than 1 cm, lymphovascular invasion, lymph node involvement, high nuclear grade and/or histologic grade, Her2-neu overexpression, hormone receptor negative status). Systemic therapy may include chemotherapy and/or hormonal therapy. Patients who are estrogen and/or progesterone receptor positive may be considered for adjuvant hormonal therapy initiated during or after the completion of radiation therapy (National Comprehensive Cancer Network, 2002).

Breast cancer is the most commonly diagnosed cancer among women in the United States. Approximately half of all patients diagnosed with early-stage breast cancer receive conservative breast surgery followed by consolidative radiation treatment. A number of technologic advances have been made in radiation therapy planning and treatment that minimize early and late toxicities and may improve treatment outcomes. Among these are (a) the treatment of patients with large or pendulous breasts or cardiopulmonary disease in the prone position, (b) intensity-modulated radiation treatment, which delivers precise, highly conformal radiation dose distributions within the breast by using computerized inverse treatment planning and intensity-modulated radiation beams to produce the required dose distribution, and (c) brachytherapy, which is the placement of a radioactive source within the lumpectomy bed. These advances are gaining national recognition and are available at many institutions. Nurses play a vital role in educating patients; therefore, nurses must have the information they need to inform their patients about these advances. The information in this article will allow nurses to help patients understand the anticipated treatment and related side effects and make informed decisions.

**Key Words:** breast neoplasms, radiotherapy; brachytherapy

Radiation Therapy

Patients undergoing breast-conserving therapy receive radiation after lumpectomy with the goal of eradicating residual microscopic cancer cells to minimize locoregional recurrence (Lichter, 1998). Careful planning before the start of radiation ensures correct dose distribution of radiation to the target area and minimal exposure to surrounding normal structures (i.e., heart, lung, ribs). In patients who do not require adjuvant chemotherapy, radiation therapy typically begins three to four weeks after surgery. This allows for adequate healing of the lumpectomy incision site. On occasion, wound dehiscence, maceration, postoperative infection, or hematoma formation may delay the initiation of radiation. Otherwise, radiation is started one month after the last cycle of chemotherapy.

Traditionally, a patient is treated in a supine position with the arm on the affected side elevated above the head to ensure that the arm is out of the treatment field. An immobilization device is made to ensure reproducibility of the treatment position each day (see Figure 1). Radiation is administered to the entire breast using photon beams aimed in opposing tangential fields. The breast is irradiated with a dose of 180–200 cGy, Monday through Friday, three to four weeks after surgery.

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Friday, to a total dose of 45–50 Gy over a period of five to six weeks (Morrow et al., 2002). Depending on margin status and risk for local recurrence, a boost dose to the lumpectomy bed may be given with an additional 10–14 Gy because recurrences following radiation typically are seen at or near the primary site (Morrow et al.). Patients with tumors larger than 5 cm or with four or more positive lymph nodes also require radiation to the supraclavicular fossa (Lichter, 1998). Patients who have not had SLNB or ALND also require radiation to the axilla (Morrow et al.).

Side Effects

Radiation affects cancer cells and normal cells within the treated area, and injury to normal cells results in acute and long-term side effects. Acute side effects are common and generally resolve within a month after radiation therapy. Long-term effects are rare and occur six months or later after treatment.

**Acute side effects:** Acute side effects of breast irradiation include skin changes, local edema, and fatigue. Erythema and hyperpigmentation begin after two to three weeks of treatment. Pruritus or rash can develop in areas of the breast with previous sun exposure. Moist desquamation may be seen under the breast, in the axilla, or over the clavicle and typically develops after three to four weeks of treatment (Lichter, 1998).

Radiation to the breast may cause inflammation and edema, which are experienced as a feeling of fullness in the breast, mild discomfort, or shooting pain that can be relieved with mild analgesics. Symptoms may begin after one week of treatment and can persist for months after treatment ends. Patients also may experience nipple tenderness.

Most patients undergoing radiation to the breast experience fatigue two to three weeks after treatment and commonly describe it as increased tiredness in the early evening. Fatigue may be increased in patients who have had previous chemotherapy (Dow, 1999).

**Long-term side effects:** Long-term side effects of breast irradiation include cosmetic changes (e.g., mild hyperpigmentation, telangiectasia, fibrosis), lymphedema, and damage to underlying normal structures. In addition, breast tissue may feel firmer than the untreated breast. Patients who are obese and have pendulous breasts are at higher risk for cosmetic changes (Algan, Fowble, McNeeley, & Fein, 1998).

Lymphedema of the upper extremity occurs most commonly in patients who have had ALND followed by axillary radiation (Clarke, Martinez, Cox, & Goffinet, 1982). This side effect usually is triggered by a soft tissue infection and is more common in obese patients (Meek, 1998).

Radiation damage to underlying normal structures may result in a number of long-term side effects. Radiation pneumonitis, which is characterized by dry cough, shortness of breath, and a low-grade fever, occurs in 1% of patients and is correlated with previous chemotherapy and irradiation of a third field (e.g., supraclavicular fossa in addition to the opposing tangential fields) (Crane & Baker, 1999; Lingo et al., 1991). Rib fractures occur in 2%–5% of patients; these fractures usually are asymptomatic and heal spontaneously (Lichter, 1998). Brachial plexus damage following radiation to

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**Figure 1. Patient in Supine Position on Immobilization Device**

The device above is an alpha cradle. Some institutions use a vacuum bag; the bag is filled with fluid that hardens while the patient lays in position. The air is removed while the patient rests on it, thereby leaving an imprint. Note the typical erythematous reaction often seen after the third week of external beam radiation.

**Figure 2. Patient Positioned Prone With the Breast Hanging Dependently Through the Opening of the Treatment Board**

The device above is an alpha cradle. Some institutions use a vacuum bag; the bag is filled with fluid that hardens while the patient lays in position. The air is removed while the patient rests on it, thereby leaving an implant. Note the typical erythematous reaction often seen after the third week of external beam radiation.
the axilla and supraclavicular fossa occurs in 1.8% of patients (Pierce et al., 1992) and is characterized by mild discomfort in the shoulder and numbness and weakness in the affected arm and hand.

The risk of second malignancies is very low; development of sarcoma in the radiation field reportedly is 0.2% (Taghian et al., 1991). Older studies have documented an increased incidence of myocardial damage 10–15 years following left-sided breast irradiation in patients who received higher doses to a large portion of the heart (Li, Williams, Goffinet, Boyer, & Xing, 2000), although this does not appear to be the case with modern treatment planning techniques.

Advances

Three advances have been made in the field of radiation oncology for the treatment of patients with early-stage breast cancer: treatment of patients in the prone position, intensity-modulated radiation therapy (IMRT), and refined brachytherapy techniques.

Treatment in the Prone Position

Traditionally, patients are treated in the supine position to clearly delineate the treatment field. Patients with large, pendulous breasts pose a challenge because, as breast size increases, the radiation dose will not be distributed evenly throughout the breast (Algan et al., 1998). This can result in increased acute reactions, which may require interruption of treatment and potentially can decrease local control (Mahe, Classe, Dravet, Cussac, & Cuilhier, 2002).

The use of an adjustable breast board designed for patients with large pendulous breasts can minimize the separation and dose inhomogeneity within the breast. A patient is positioned prone with the arm on the affected side raised above the head (see Figure 2). The patient is rotated slightly on her side so that the treated breast hangs dependently through the opening of the treatment board.

The contralateral breast is positioned laterally with a foam wedge that is placed under the breast to keep it out of the treatment field (Grann et al., 2000). Treatment in the prone position improves dose distribution within the breast and allows for a decrease in the dose delivered to the heart, lung, chest wall, and contralateral breast (Merchant & McCormick, 1994). Preliminary results reveal that cosmesis is excellent and that local control and survival are comparable to patients treated in the supine position (Grann et al.). However, long-term studies comparing this method to three-dimensional conformal or two-dimensional tangential approaches have not yet been conducted.

Intensity-Modulated Radiation Therapy

With conventional radiotherapy of the breast, treatment planning begins with a simulation. X-rays are taken of the treatment field in two dimensions (see Figure 3). The breast contour is outlined; the number, shape, and angle of treatment beams are defined; beam modifiers are selected; and the dose is prescribed. Dose distribution within the breast and underlying normal structures is calculated and reviewed, and the plan is improved as needed to ensure that the correct dose is targeted to the breast and that the dose to the underlying structures is minimized.

IMRT offers a new approach to the planning and delivery of treatment to reduce dose inhomogeneity within the target while sparing surrounding normal structures. A variety of IMRT techniques has been developed (Intensity Modulated Radiation Therapy Collaborative Working Group, 2001).

In one type of IMRT technique, patients undergo simulation with a computed tomography scanner to create a three-dimensional model of the breast (see Figure 4). Through the use of a computerized optimization algorithm with preset dose constraints for the breast and underlying structures, a series of intensity-modulated beams are produced to the desired dose distribution within the breast (see Figure 5). The radiation beam is shaped with a multileaf collimator (see Figure 6) that is located in the gantry of the linear accelerator. The multileaf collimator has many pairs of leaves that travel continuously across the treatment field to modulate the beam while treatment is delivered to produce the desired intensity pattern within the breast.

The use of IMRT in the treatment planning and delivery of radiation to the breast improves dose homogeneity and further reduces radiation exposure to underlying structures (e.g., heart, lung, contralateral breast) (Chui, Hong, Hunt, & McCormick, 2002; Hong et al., 1999; Vicini, Sharpe, et al., 2002). Acute toxicity is minimal (Kestin et al., 2000), and according to some researchers, cardiac toxicity can be reduced by 50% in some patients (Hurkmans, Cho, Damen, Zijp, & Mijnheer, 2002). More research is needed to evaluate the impact of IMRT on acute and long-term side effects, local recurrence, and survival.

Brachytherapy

Most cancer recurrences in the breast (67%–100%) occur at or near the lumpectomy site, which is why the site receives a boost dose of radiation when external beam...
Brachytherapy now is being investigated as a primary radiation treatment following breast conservation surgery in selected patients with early-stage breast cancer as an alternative to whole breast irradiation (Baglan et al., 2001; Polgar et al., 2002; Vicini, Baglan, et al., 2002). The American Brachytherapy Society suggested adherence to strict guidelines (see Figure 7) when selecting patients for breast brachytherapy (Nag, Kuske, Vicini, Arthur, & Zwicker, 2001). By following these criteria, preliminary results suggest a local control rate of 96%–100% (Polgar et al.).

Brachytherapy to the breast is administered most commonly through flexible afterloading catheters that are positioned in the tumor bed after resection of the breast tumor (see Figure 8). Low-dose rate sources in the form of ribbons with iridium-192 or Positive prognostic factors
- T1 or T2 disease
- Node-negative histology
- Unifocal disease
- Invasive ductal carcinoma
- Lesions smaller than 3 cm
- Lumpectomy with axillary dissection
- Negative margins

Negative prognostic factors
- Invasive lobular carcinoma
- Extensive ductal component
- Paget’s disease of the nipple
- Collagen vascular disease
- Patients not candidates for breast-conserving therapy

Brachytherapy now is being investigated as a primary radiation treatment following breast conservation surgery in selected patients with early-stage breast cancer as an alternative to whole breast irradiation (Baglan et al., 2001; Polgar et al., 2002; Vicini, Baglan, et al., 2002). The American Brachytherapy Society suggested adherence to strict guidelines (see Figure 7) when selecting patients for breast brachytherapy (Nag, Kuske, Vicini, Arthur, & Zwicker, 2001). By following these criteria, preliminary results suggest a local control rate of 96%–100% (Polgar et al.).

Brachytherapy to the breast is administered most commonly through flexible afterloading catheters that are positioned in the tumor bed after resection of the breast tumor (see Figure 8). Low-dose rate sources in the form of ribbons with iridium-192 or
iodine-125 seeds then are loaded into the catheters for one to three days, depending on the desired dose to be delivered (45–50 Gy). Patients remain hospitalized throughout treatment, and after treatment, the ribbons and catheters are removed (Vicini et al., 1997).

Alternatively, high-dose rate iridium sources deliver treatment over 10–20 minutes. The total dose is fractionated and delivered twice daily, over four to five days, for a total dose of approximately 34 Gy (Baglan et al., 2001). One device in use is the Mammosite® Radiation Therapy System (Proxima Therapeutics, Inc., Alpharetta, GA) that consists of a long catheter ending in a balloon-like structure that is placed in the lumpectomy cavity after removal of the tumor (see Figure 9). The balloon is instilled with saline and left in place with the catheter protruding from the skin (see Figure 10). After the catheter is placed, the radioactive source is introduced into the balloon via a high-dose rate remote afterloader, eliminating exposure to staff (see Figure 11). At the completion of the last treatment, the source and catheter are removed (Keisch et al., 2003).

A significant advantage of brachytherapy is the improved quality of life for patients whose course of radiation is measured in days rather than weeks. The inconvenience associated with a six-week course of external beam radiation therapy has been one of the primary deterrents for breast-conserving therapy in patients who opt for mastectomy or refuse adjuvant treatment altogether. An additional potential advantage of brachytherapy is that it eliminates the need to delay radiation therapy. Techniques to further improve the planning and delivery of brachytherapy are being explored to better delineate the target volume to be treated with the goal of further improving clinical outcomes. Nurses should follow ongoing trials that evaluate efficacy as well as acute and long-term side effects.

Implications for Practice

Patients who are diagnosed with breast cancer need to participate in making treatment decisions. The first decision, whether to have a lumpectomy followed by radiation or a mastectomy, often is made during or shortly after the initial consultation visit. Subsequent decisions may include where to have treatment (i.e., at a major cancer center or a local radiation facility), what type of treatment to pursue (i.e., whole breast or partial breast irradiation), and whether to seek out newer techniques (i.e., IMRT or brachytherapy) over standard therapy. Because radiation therapy often is not well understood, these decisions may be met with anxiety, stress, and apprehension. Keeping in mind that certain patients may not be candidates for particular types of treatment (i.e., a

**Figure 9. Mammosite Radiation Therapy System**

*Note: Reprinted with permission from Proxima Therapeutics, Inc.*

**Figure 10. Mammosite Radiation Therapy System in the Breast**

*Note: Reprinted with permission from Proxima Therapeutics, Inc.*

**Figure 11. High-Dose Rate Remote Afterloader**

*Note: Image courtesy of Varian Medical Systems, Inc. All rights reserved.*

**Figure 12. Patient Education for Treatment With External Beam Radiation Therapy**

*Note: Image courtesy of Varian Medical Systems, Inc.*
small-breasted woman may not be a candidate for prone positioning) or may not benefit from particular techniques, nurses must be familiar with and able to describe these new procedures and their risks, benefits, and outcome data, so that patients can make informed decisions. Providing accurate information about these technological advances is a major responsibility of radiation oncology nurses and is essential to alleviate concerns that patients may have about the daily impact of treatment on their lives.

After assessing patients’ informational needs, information must be delivered clearly and concisely initially and at appropriate intervals throughout treatment to ensure comprehension. This can be accomplished using a variety of teaching methods: visual, written, and verbal. A self-directed CD-ROM program can be developed to educate patients about breast cancer and treatment options. Visual images can illustrate the difference between IMRT and standard radiation therapy. Patients receiving treatment in the prone position may benefit by seeing the breast board before the simulation. Many patients will benefit from seeing the treatment room and hearing about the sensations they may experience during treatment. These strategies will help patients to feel more comfortable, and research has shown that the strategies result in less disruption of usual activities during and after radiation treatment (Johnson, Fieler, Jones, Wlasowicz, & Mitchell, 1997). Figure 12 and Tables 1–3 list content that should be included in the teaching of patients with breast cancer undergoing these technological advances in radiation therapy.

### Conclusion

Ongoing research is needed to determine whether radiation treatment advances minimize early and late toxicities and, most importantly, improve patient outcomes. Oncology nurses play a vital role in educating patients about their options, preparing them for treatment, managing side effects, and supporting them through recovery.

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Table 3. Patient Education for Treatment Administration of Brachytherapy

<table>
<thead>
<tr>
<th>Teaching Topics</th>
<th>Low-Dose Rate</th>
<th>High-Dose Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Applicators</td>
<td>Inpatient Catheter(s) placed at time of lumpectomy or re-excision or within eight weeks after surgery</td>
<td>Outpatient Catheter(s) placed at time of lumpectomy or re-excision or within eight weeks after surgery</td>
</tr>
<tr>
<td>Loading of sources</td>
<td>Manual One to three days</td>
<td>Remote afterloader 10–20 minutes for each treatment</td>
</tr>
<tr>
<td>Duration of treatment</td>
<td>One treatment</td>
<td>8–10 treatments given twice daily over four to five days</td>
</tr>
</tbody>
</table>

References


Veronesi, U., Cascinelli, N., Mariani, L., Greco, 635


For more information on this topic, visit the following Web sites.

**Radiation Therapy Oncology Group**
www.rtog.org

**Radiation Therapy and You**
www.cancer.gov/cancerinfo/radiation-therapy-and-you

**MEDLINEplus: Radiation Therapy**

*Links can be found at www.ons.org.*

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**Rapid Recap**

**Advances in Radiation Treatment of Patients With Breast Cancer**

- Many women diagnosed with early-stage breast cancer receive conservative breast surgery followed by radiation treatment.
- Technologic advances in radiation therapy delivery can minimize early and late toxicities and may improve treatment outcomes.
- Patients with large, pendulous breasts or cardiopulmonary disease should be considered for treatment in the prone position.
- Intensity-modulated radiation treatment uses computerized inverse treatment planning and delivery of intensity-modulated radiation beams to produce optimal dose distributions.
- One method of delivering partial breast irradiation is brachytherapy, in which a radioactive source is placed in or in close proximity to the tumor or tumor bed. The efficacy of breast brachytherapy is being investigated in comparison to conventional external beam radiotherapy.