Abstract

There are currently several treatment options available to women who have been diagnosed with breast cancer. These treatments include surgery, radiation therapy, chemotherapy, and hormone therapy. Each method of treatment has been proven to benefit most patients in some way. When treatment options are combined the chances of eliminating the cancer entirely are greatly increased. Surgery paired with either whole breast irradiation or accelerated partial breast irradiation is a proven method to increase the rates of survival in breast cancer patients. Surgery paired with whole breast irradiation is the standard of breast conserving cancer treatments. Accelerated partial breast irradiation is an acceptable alternative to whole breast irradiation because it can provide a significantly lower radiation dose to breast cancer patients.
Introduction

Breast cancer is a very serious public health issue today since it occurs in one out of every eight women (Wilson, Miller, Edge, 2012, p. 42). It is a complex disease with several different types of treatment available after initial diagnosis. The treatment options currently available to patients whom have been diagnosed with breast cancer are surgery, radiation therapy, chemotherapy, and hormone therapy. The main purpose of these therapies is to eliminate the cancer, avoid the production of metastases, and prevent future remission. Each of these therapies can be somewhat effective when it comes to treatment, however they are more effective and the chance of remission greatly decreases when more than one therapy is used. Surgery paired with a form of radiation therapy is a very effective and proven method of treating breast cancer.

Literature Review

Surgery is the first line of defense in the battle against breast cancer because it achieves local control of the primary breast cancer tissue and prevents dispersion to the axillary lymph nodes. Surgical treatment for breast cancer patients is a daunting prospect since there will often be fear of disfigurement and pain. Radical mastectomy was formerly the only option for the management of breast cancer. Radical mastectomies include the removal of the breast and often the associated axillary lymph nodes. Surgical management of the axilla is important because breast cancer can move to the axillary lymph nodes. Clearing the axillary lymph nodes provides the patient with control of the disease and is an important indicator of future prognosis. Ernst et al. (2002) as cited by Blowers and Foy (2009) found that axillary clearance can lead to the development of lymph swelling, known as lymphedema, and the reduced function of the affected arm and shoulder. Sentinel biopsy is becoming more common in the treatment of breast cancer.
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Sentinel biopsy is performed to detect whether or not the cancer has spread into the first axillary lymph node. If no cancer is found in the sentinel lymph node then axillary surgery will not be required and the potential for further dispersion of the disease is reduced (Blowers & Foy, 2009, p.282).

Treatment has drastically changed over the past few decades to focus more on conservative breast surgery rather than mastectomy. Radical mastectomies began to be replaced with breast conservation surgeries such as lumpectomies and quadrantectomies. A lumpectomy consists of removing breast tumors along with the surrounding area of local tissue. The lymph node will then be evaluated with sentinel biopsies and then be followed by radiation therapy (Loukas et al., 2011, p. 570-571). In a quadrantectomy, the quarter of the breast containing the cancerous tissue is removed. Conservative breast surgery alone is not as effective as a radical mastectomy in terms of eliminating the tumor and decreasing chances of recurrence. Conservative surgical treatment of breast cancer combined with treatment such as postoperative radiotherapy has been proven to be equally effective as a radical mastectomy (Sakorafas & Safioleas, 2010, p. 152).

**Radiation Therapy**

Radiotherapy uses high energy ionizing rays to damage breast cancer cells. The most important part of radiotherapy for breast cancer is matching a valid treatment plan with patient diagnosis. Powell (2010) states that the emphasis on breast cancer treatment is to maintain local control and reduce toxicities from the treatment. This can often be difficult due to biological factors and what stage of breast cancer the patient may be in. Whole breast irradiation (WBI) or accelerated partial breast irradiation (APBI) are two radiation treatments available to breast cancer patients.
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Whole Breast Irradiation

Ferraro et al. (2012) explain that the standard method of administering breast radiation for breast cancer is WBI. WBI paired with breast conserving surgery such as lumpectomy is just as effective in terms of long term survival as mastectomy (p.53). WBI delivers a radiation dose between 50-60 Gray (Gy) over the course of five to six weeks (Njeh, Saunders, & Langton, 2010, p.91). WBI combined with lumpectomy reduces the chances of recurrence by 60-70% when compared to lumpectomy alone (Falk, 2009, p. 9). Adding WBI benefits the patient by reducing loco regional recurrence in the same quadrant as the initial tumor being treated. WBI does not reduce the risk of recurrence in other quadrants of the breast.

Accelerated Partial Breast Irradiation

The alternative to WBI is APBI which allows for a lower radiation dose. APBI is a form of internal radiotherapy, or brachytherapy. APBI treatments are meant to give a uniform dose of radiotherapy to the breast in an accelerated fashion that provides a homogenous dose (Falk, 2009, p. 10). The lower radiation dose from APBI allows the breast cancer patient to avoid problems associated with WBI such as skin toxicity, fibrosis, and fat necrosis. APBI delivers localized and targeted radiotherapy to the breast via catheter or interstitial catheter. APBI treatments are meant to give a uniform dose of radiotherapy to the breast in an accelerated fashion while providing minimal to no radiation exposure to the uninvolved and normal breast tissue. The radiation is administered only in the lumpectomy bed, with the radiation fraction size increasing. Falk (2009) found that other benefits of APBI include: decreased treatment time, consistent and reproducible radiation dosing, and decreased radiation to the heart and lungs (p10). There are several approaches now available to administer APBI. Methods of implementing APBI include: multi-catheter interstitial brachytherapy, balloon catheter
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brachytherapy, 3D-conformal radiation therapy, and intra-operative radiation therapy. Each technique contains varying strengths and weaknesses due to factors such as invasiveness, radiation administration, proficiency of the operator, and the length of treatment (Njeh et al., 2010, p.92).

Methods of Implementing APBI

Multi-catheter interstitial brachytherapy (MIB)

Multi-catheter interstitial brachytherapy (MIB) is the method of APBI treatment that has been used longest. In MIB, 14-20 flexible after loading catheters are placed in breast tissue surrounding the site of the lumpectomy (See Figure 1). The formations in which the catheters are arranged in respect to the tumor target volume are fundamental for effective treatment. Implementing computed tomography (CT) into the planning and guidance of catheters is effective because it allows for greater treatment accuracy. Either low dose rate (LDR) or high dose rate (HDR) brachytherapy can be used with MIB. In LDR procedures, sources of Iridium-192(Ir-192) are implanted into the patient for about two to five days. HDR procedures include fractionating radiation over the course of a week (Njeh et al., 2010, p.92-93).

Balloon catheter brachytherapy

Balloon catheter brachytherapy can be administered through three different systems which are the MammoSite, Axxent electronic brachytherapy, and Contura systems. The Mammosite brachytherapy system (MSB) is designed to allow for reproducibility, easy application, and better tolerance. A Mammosite catheter consists of a silicone balloon with a small inflation channel and a channel for the radiation source which is to be injected. The process of using Mammosite brachytherapy includes filling the balloon with saline solution and contrast for visualization, and then inserting Ir-192 into the catheter. The Ir-192 source is
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connected to a computer controlled HDR loader which delivers the prescribed radiation dose. The applicator used in the MSB system can be placed in the lumpectomy cavity either during surgery or after the surgery using ultrasound guidance. Following the placement of the applicator CT is used to evaluate the quality of the implant and plan for future radiation. The quality of the implant is determined by three factors which are: balloon conformance to the lumpectomy cavity, distance from the surface of the balloon to the skin surface, and the symmetry of the balloon in relationship to the central catheter. These factors are very important in terms of dosimetry and future cosmesis. MSB may not be appropriate for patients with small breasts or for tumors found in the upper inner quadrant because of inadequate skin-to-cavity distances (Njeh et al., 2010, p.93-94).

The Axxent electronic brachytherapy system is a modified version of balloon based brachytherapy. Like the MSB system a balloon catheter is inserted into the lumpectomy cavity, however a 50 kilo-volt x-ray source is used as the radiation source instead of Ir-192. The x-ray source is comprised of a small x-ray tube which is inserted into the balloon catheter. Some of the main advantages of the Axxent system are that it is very portable allowing access to a variety of patients and it also provides a lower radiation dose than the MSB system when a long cavity to skin distance cannot be utilized. The balloon catheter of the Contura device is similar to the MSB system because Ir-192 is used; however it is delivered through a central lumen and four other channels as shown in Figure 2. The additional channels in the Contura system are fixed 5 mm away from the central channel of the catheter. The extra channels allow for more dose flexibility and can also reduce the dose to tissues of the chest wall, skin, heart and lungs (Njeh et al., 2010, p. 95-97).

3D-conformal radiation therapy (3D-CRT)
3D-conformal radiation therapy (3D-CRT) is classified as external beam radiation therapy (EBRT) which means that the radiation used to treat the tumor is coming from outside of the body. Baglan et al. (2003) as cited in Njeh et al. (2010) describe the most commonly used technique of 3D-CRT as using four to five tangentially positioned non-coplanar beam that deliver 3.85 Gy twice daily to the tumor bed. EBRT has many advantages over techniques such as MIB and balloon catheter brachytherapy. EBRT is non-invasive which allows the patient to not be subject to a second surgical procedure, and in turn reduces the risk of complications. EBRT has the potential to be available to many breast cancer patients since most radiation therapy centers today are capable of performing 3D-CRT for a variety of other cancers. Formenti (2005) as cited in Njeh et al. (2010) states, “that an external beam approach will be easier for radiation oncologists to adopt than brachytherapy techniques because the technical demands and quality assurance issues are much simpler” (p.11). Another advantage is that the outcome of EBRT is not as dependent on factors such as the experience and skills of the person performing the procedure, when compared to brachytherapy. When technical issues arise during EBRT the procedure is not aborted as frequently as in brachytherapy. EBRT is also more likely to generate better dose homogeneity and results in a more favorable cosmetic outcome.

APBI using EBRT still has issues that arise from factors such as breathing motion, variation in treatment setups, and the implemented fraction scheme. Breathing motion can lead to target movement which may cause the patient to be in varying positions during different radiation fractions. Due to this variance a larger treatment volume must be used to compensate for the movement and avoid missing the planned target. A method to reduce target motion is placing the patient in a prone position as opposed to supine. The prone position not only reduces motion, but decreases the dose of radiation given to heart and lung tissues. Although there are
several advantages the prone position is still not widely accepted during EBRT treatments, because it requires unique immobilization devices and is uncomfortable for many patients (Njeh et al., 2010 p. 99-100).

One major disadvantage of EBRT is the cosmetic side effects. EBRT can cause skin irradiation ranging from erythema, peeling, ulceration, and necrosis known as skin toxicity (Schnur, Ouellette, Dilorenzo, Green, & Montgomery, 2011, p.266). Skin toxicity from radiation therapy can cause changes in skin color and texture of the affected breast. Besides the physical effects of skin toxicity, emotional suffering due to the change in cosmesis must also be addressed.

**Intra-Operative Radiation Therapy (IORT)**

In IORT a single fractional dose of radiation is delivered directly to the tumor bed during breast conservation surgery. There are three systems that IORT can be delivered by which are: Intrabeam, Mobetron, and the Novac-7. The Intrabeam system uses low energy x-ray photons to irradiate the lumpectomy cavity. The Intrabeam system provides minimal radiation to the patient and staff. Within the Intrabeam device the x-ray photons are distributed through spherical applicators which match the size of the lumpectomy cavity. The x-ray photons are then distributed in a consistent dose to the tumor bed. Placing sutures within the breast can when using the Intrabeam system can assist in holding breast tissue against the applicator to get a more uniform dose (Njeh et al., 2010 p.103-105).

The Mobetron and Novac-7 systems both use electrons to irradiate the tumor bed. The Mobetron system is made up of three components which are the control console, the modulator, and the therapy module. The purpose of the Mobetron control console, which is outside of the operating room (OR), is to control the accelerator. Having the control console outside of the OR
means that the radiation treatment is remotely controlled by medical personnel and provides no radiation dose to the surgical team. The modulator contains the accelerator which in turn produces the electrons used for therapy. The therapy module is the piece of the Mobetron that actually delivers the electrons which are to be used in therapy. The Novac-7 distributes electrons with a mobile linear accelerator and can deliver electron beams at four different energies. The accelerator that produces the electrons is mobile in the Novac-7 system. The capabilities of equipment such as the Mobetron and Novac-7 make it exceptionally expensive, which means that women in poorer countries do not have the option of IORT using electrons (Njeh et al., 2010, p. 105-106).

One of the main advantages of using IORT as opposed to other methods of brachytherapy is that the cancer cells are being irradiated before they even have the chance to multiply. Tissues under surgical intervention are also much more susceptible to irradiation due to their high vascularization and high level of aerobic metabolism. The risk of patients not completing their prescribed plan of radiotherapy is removed when IORT is used. IORT also eliminates the risk of geographical miss. Geographical miss is when the radiation dose is inaccurately or incompletely delivered to the tumor bed and can often happen when EBRT is used. Geographical miss can be the result of patient movement, inconsistent setup, and difficulty finding the tumor site post-surgery. IORT is also more cost effective for the patient because one fraction of radiation is given instead the typical treatment of about 25 fractions (Njeh et al., 2010, p.104).

**Discussion**

The treatment of breast cancer has changed drastically over the past few decades. Radical mastectomy was formerly the only option available to a woman diagnosed with breast cancer.
There are currently multiple and varying treatments available to breast cancer patients that can conserve breast tissue much more effectively than a radical mastectomy. Surgeries such as lumpectomies or quadrantectomies in terms of cosmesis are the preferred alternative to a complete mastectomy. Lumpectomies and quadrantectomies paired with radiation therapy, either WBI or APBI, are just as effective as a radical mastectomy in terms of breast cancer treatment. WBI paired with surgery is the standard method of treating breast cancer conservatively. WBI has been proven to be just as effective, if not more so than a radical mastectomy. APBI, the alternative to WBI offers a lower radiation dose. APBI can be as effective as WBI if the correct treatment plan and system are chosen. Falk (2009) states that APBI appears to be an acceptable option for definitive radiation treatment for patients who desire breast conservation. The current systems of delivering APBI are MIB, balloon catheter brachytherapy, 3D-CRT, and IORT. Each system has various methods of administering the radioactive source to the tumor bed. Each method also has its own set of advantages and disadvantages. Of the current methods of administering APBI, IORT is probably the most effective and convenient method of treatment for breast cancer patients. IORT offers convenience because patients do not have to return for further radiation treatments and will also no have to undergo more invasive procedures following their already invasive surgery. IORT is also more effective than the other systems such as 3D-CRT, because the risk of geographical miss is eliminated. Although IORT is a very effective method, it may not always be an option to patients because many treatment centers and hospitals may not carry equipment such as the Intrabeam, Mobetron, or Novac-7 due to high costs. Women diagnosed with breast cancer currently have many more preferable options of treatment available to them that were not available even two decades ago. The progression of technology in
the field of breast cancer treatments has transformed breast cancer from a death sentence into a battle that can be won with the right course of action.
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Figures

Figure 1. Multi-catheter interstitial brachytherapy use 14-20 flexible after loading catheters placed in the breast tissue around the lumpectomy site. Iridium-192 is implanted into the patient through these catheters.

![Catheters](image1)


Figure 2. The Contura device has multiple lumens for Ir-192 to pass through. It contains a central lumen along with 4 surrounding channels to house the high dose rate source.

![Contura Device](image2)

References


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