Supine Versus Prone: An Examination of Advantages and Disadvantages in Positioning for Breast Radiotherapy

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Abstract

The purpose of this literature review was to examine the current published works available concerning differences in supine and prone setups for radiation therapy of the breast in an attempt to determine the advantages and disadvantages of each setup. The review includes different treatment options, such as systemic and local, the various forms of radiotherapy that may be administered, as well as the treatment fields, target volumes, and organs at risk. The supine and prone treatment positions were then reviewed separately to determine their own individual benefits and drawbacks. The review concludes that most women who receive whole breast irradiation following breast conserving surgery will obtain the most benefits from a prone treatment setup due to the substantial decrease in dose to the organs at risk. However, in certain cases, such as for women with small breast size, the supine setup is still ideal for treatment.
Introduction

Breast cancer is the most common malignant disease affecting women. Nearly two million cases were diagnosed worldwide in 2012 alone. Throughout history, radiotherapy has been pivotal in the treatment of breast cancer. Until recently, the supine position has been the industry standard. In more recent years, different positioning techniques have been utilized in an attempt to maintain proper dose distribution to the target areas while decreasing incidental dose to non-target tissues. The prone position has become the primary alternative position. Many advantages of this positioning have been identified, but they are not without their own set of drawbacks. There are cases in which a supine position is still preferable. While each patient and disease presentation is different, every effort should be made to utilize the positioning technique which will obtain maximum effective treatment while minimizing potential negative consequences.

Methodology

A review of the literature was performed which included published works from the years 2006 to 2015. The literature gathered was related to breast cancer treatments available, types of breast radiotherapy, and differences in positioning for breast irradiation. Various resources were utilized for gathering information. Research databases utilized included MEDLINE via PubMed and Google Scholar, both of which were used to retrieve online articles. Keyword searches for the literature included “prone breast radiation,” “breast cancer treatment options,” “supine breast irradiation,” and “breast radiotherapy treatment fields.” Articles were selected based on their inclusion of comparisons between prone and supine breast irradiation, as well as types of breast
cancer therapies, to include specifics on breast radiotherapy. Sixteen of the 23 articles originally selected were used as references in this literature review. Both original research and review articles were included, all of which were from peer-reviewed journals. Additional resources included in the research were a breast radiotherapy textbook and governmental and professional webpages.

Discussion

Treatment Options

There are a multitude of treatment options available for breast cancer. The various forms of treatment can be broadly categorized as either systemic or local. Systemic therapies treat the entire body, to include areas unaffected by the cancer.\(^2\) Local therapies include therapies which treat only the part of the body directly affected by the cancer, such as the tumor site. Due to the complexity of the disease, multiple treatment modalities are often utilized. Systemic therapies which may be employed include chemotherapy, hormone therapy, and targeted therapy. Local therapies, often used in conjunction with one another, include surgical resection and radiotherapy.\(^1\)

Systemic therapies for breast cancer are often utilized in an attempt to reduce the size of the primary tumor. This allows for a reduction in the magnitude of local surgery as well as increasing the chances of breast conservation. Systemic therapy has also been shown to reduce local recurrence of disease.\(^3\) The most common form of systemic therapy is chemotherapy, which utilizes chemical substances introduced into the body to stop or slow the growth of the cancer cells. As with chemotherapy, hormone therapy can be used to stop or slow the growth of cancer, but it can also be used to decrease the
chances of recurrence. Hormone therapy is utilized in the treatment of breast cancer because the disease requires hormones to enable it to grow. Targeted therapy is the most precise form of systemic cancer treatment. With targeted therapy, the treatment targets the changes in cancer cells that allow them to divide and spread and blocks their effects. The precision of this form of treatment allows for increased sparing of healthy tissue.

Local therapies began as the primary method of care for breast cancer. Surgery has been an effective means of treatment for well over a century. Surgical options include mastectomy, with or without removal of lymph nodes, as well as breast-conserving therapy, depending upon the advancement of the disease. Mastectomy refers to full removal of breast tissue, while breast-conserving therapy involves the removal of the cancerous tissue while preserving any remaining breast tissue.

Radiotherapy, also known as radiation therapy, is a form of localized cancer treatment that requires the use of high-energy doses of radiation to shrink tumors as well as kill cancer cells. The effects of radiation therapy are not immediate and treatments generally last for several weeks so that they may be most effective. Radiotherapy can be delivered via two different methods: external beam radiation or internal radiation. With external beam radiation therapy, a focused beam of radiation is directed from a machine toward the specific site of the disease. Internal radiation for breast cancer is a form of radiotherapy in which a solid source of radiation is placed within the breast near the cancer site. The use of an internal solid source of radiation is also known as brachytherapy. Radiotherapy has evolved a great deal over the years, and while there is a vast array of topics in this area, this review will focus on modern external beam radiotherapy.
Radiotherapy Treatment Types and Fields

When performing radiotherapy following breast conserving surgery, the use of tangential fields is necessary. The most conventional method of breast irradiation involves two opposing tangential beams. This method is known as conventional tangential technique (CTT). The tangential fields will angle the beam, which allows for full coverage of the breast tissue while minimizing the dose to underlying healthy tissue, such as the heart and lungs. Wedges are generally added to the beams to account for the change in shape of the breast and to distribute the dose more evenly across the breast.

Another common and more advanced technique that may be employed in breast irradiation is intensity modulated radiotherapy (IMRT). IMRT is a method of conformal radiation, in which the radiation beams are shaped to match the shape of the tumor. Multiple small beams are used during IMRT. The beams have differing intensities for increased accuracy in irradiating the tumor. Along with the varying beam intensities, the beam is also able to change shape during the treatment. The goal of IMRT is to more precisely conform to the target area while sparing adjacent tissues. The increased precision permits for an increased dose to the tumor.

Many of the healthy tissues adjacent to the treatment site of the breast are categorized as organs at risk (OAR). In general, all of the breast tissue to be treated is defined as the target volume, and this is the area receiving the greatest dose of radiation. Surrounding structures such as the ipsilateral lung, heart, contralateral breast, and contralateral lung are the OAR during radiation therapy of the breast (Figure 1).
One of the keys to proper breast radiotherapy is to exclude the organs at risk from
the treatment fields without compromising the effective coverage of the target volumes.\textsuperscript{8}
Due to the increase in occurrences of long-term complications following radiotherapy,
heart and lung doses must remain as low as possible.\textsuperscript{7} Some of the most frequent late
complications of overexposure to OAR include lung fibrosis, cardiovascular events, and
secondary cancers. One of the easiest ways to protect organs at risk during breast
irradiation is individual patient positioning.\textsuperscript{9}

\textit{Treatment Positions}

Radiation therapy of the breast in both the supine and prone positions ensures
adequate coverage of the target breast as well as comparable dose homogeneity in
patients with small to average sized breasts. Long-term outcomes in regard to local and
regional control are also similar for supine and prone treatment positions.\textsuperscript{10}
The standard treatment for women with early breast cancer following breast conserving surgery is radiation therapy in the supine position.\textsuperscript{11} Treatment in this position requires the patient to lie on her back on a breast board (Figure 2).\textsuperscript{12} The arm on the affected side is raised above the head and placed into the supports, while the arm on the unaffected side can either be relaxed to the side or placed above the head as well. The head of the patient is turned toward the unaffected side. All head and arm supports are in the same position on the board for every treatment to ensure continuity and reproducibility among treatments.

![Figure 2. Supine breast board (A) on CT couch for simulation and (B) with patient in position for simulation.\textsuperscript{12}](image)

While supine breast radiotherapy is still very commonplace, the research presented very limited advantages to performing treatments in this position. One advantage to supine therapy is the increased accuracy in repositioning that is able to be obtained.\textsuperscript{9} This is a major advantage when considering that the exact same position must be achieved every day for the course of a treatment that may run for many weeks. Increased positioning accuracy can also be equated to shorter overall treatment times, allowing more patients to be seen and treated throughout the day.\textsuperscript{13}
Supine breast irradiation is also advantageous for women with small breast size. When prone, smaller breasts do not have the volume to be pulled away from the chest wall by gravity; however, the heart moves anteriorly within the chest, bringing the heart closer to the breast. When supine, the heart lies more posteriorly within the chest. The supine position leads to the ability to maximize the distance between the heart and the target breast, limiting irradiation of the heart. Research regarding deep inspiration breast hold (DIBH) found that dose to the heart in the supine position can be further reduced up to 40 percent by utilizing this technique. The DIBH technique requires the patient to hold in their breath while the radiation is being delivered. The deep inspiration further increases the distance between the chest wall and heart, leading to the reduction in dose.

Investigation of supine positioning has discovered a wide range of respiratory related motion of the target tissues when not utilizing a specific breathing technique during treatment. Researchers observed increased movement of the lateral and superior aspects of the breast compared to the medial aspect. Movement of the chest wall equates to movement of the breast, and therefore, movement of the tumor that the beam cannot follow. While respiratory motion is tracked and taken into consideration during the planning stage of treatment, the movement may still prevent an ideal level of dose precision.

Breast size is a common factor taken into consideration when determining treatment position. Disadvantages to supine breast radiotherapy can be seen when treating women with large, pendulous breasts. A large breast will generally wrap around the chest wall, increasing the non-target volume of tissue that will be included in the
treatment field. Greater gantry angles must be utilized to achieve sufficient coverage of the breast tissue, thus increasing the volume of irradiated lung. The broader shape of the breast may also lead to a decrease in the consistency of the dose to the target volume.\textsuperscript{16}

Further drawbacks to supine radiotherapy of the breast include poor cosmetic outcomes due to skin toxicity. When supine, the breast rests against the skin of the abdomen in the area of the inframammary fold. The skin on skin contact amplifies the radiation dose to the skin. For these patients, it is not uncommon to develop moist desquamation or peeling of the skin, leaving the skin painful and raw. Once moist desquamation has developed, it leaves the patient more vulnerable to further infections of the skin.\textsuperscript{17}

Many of the disadvantages of supine breast radiation therapy can be counteracted by placing the patient in the prone position. Historically, breast irradiation in the prone position was primarily reserved for women with large pendulous breasts. The modification from the standard supine position for these cases led to a decrease in acute and late skin toxicities, especially in the area of the inframammary fold.\textsuperscript{18} In the study by Varga et al,\textsuperscript{9} Grade 1 radiodermatitis was reported by 17 percent fewer patients and Grade 2 by 15 percent fewer patients who were receiving prone instead of supine treatments.

While breast size is still one aspect considered when determining radiotherapy positioning, numerous other factors may also be taken into consideration now as well. Many research studies have been performed on prone breast irradiation, and the outcome has been an increased awareness of the multiple advantages of administering radiation
therapy in the prone position. The work by Lakosi et al.\textsuperscript{11} states that, “Any achievable reduction in irradiated non-target volume without compromising target coverage is a meaningful step towards better treatment.” The reduction of irradiated healthy tissue is a major focus of research into prone breast radiotherapy and may be considered the greatest advantage.

Researchers have observed that prone breast radiotherapy leads to a significant decrease in dose to the OAR, especially the ipsilateral lung. The results from one study show a decrease in mean lung dose from $7.45_{\text{Gy}}$ in the supine position to $2.02_{\text{Gy}}$ when prone.\textsuperscript{9} The shape of the breast, as well as the chest wall, changes when the patient is placed prone, thereby substantially reducing the volume of lung included in the treatment field. The difference in tangential beam angle and treatment fields are demonstrated in Figure 3.\textsuperscript{8} There is a significant difference in the amount of lung tissue included within the two treatment fields.

Figure 3. CT treatment planning slices representing treatment fields (red line) in the supine (A) and prone (B) position for the same patient.\textsuperscript{8}
A 2015 study utilizing four dimensional (4D) CT showed that respiratory related movement is greatly diminished in the prone position. The decrease in dose to the anterior lung segment in the prone position suggests that chest wall movement is substantially decreased when prone. Patient motion during planning and treatment was not significantly affected by breast side, breast quadrant location of the tumor, breast size, or patient age or weight.

In patients with smaller breast sizes, prone positioning has not been consistently shown to reduce irradiation of the heart. In prone positioning with small breasts, less breast tissue is able to be pulled away from the chest wall, while the heart and left anterior descending coronary artery (LAD) are displaced anteriorly, closer to the treatment fields. So while typically less tissue outside of the target volume is irradiated while prone, the heart moves anteriorly when prone, placing the heart closer to the treatment field and counteracting some of the potential benefits. Research study results have been found to be inconsistent as to whether or not there is a greater decrease in dose to the heart and its structures in the prone or supine position for the majority of patients. In general, radiation dose to the heart and LAD varies among patients. Due to the potential for differences, each case must be considered individually during the simulation and treatment planning stages.

Simple dose factors alone are not the only considerations for prone positioning. There are a number of other indications for prone breast irradiation. These may include, but are not limited to, an inability to tolerate the supine position because of restricted shoulder mobility, previous chest wall radiation, significant cardio-pulmonary disease, breast size, and extensive tobacco use. While some of these relate to dose to OAR,
which would generally be diminished if treated prone, dose is not necessarily the only
deciding factor.

Patient setup for prone breast radiotherapy requires the patient to lay face-down
on a padded support affixed to the top of the treatment couch. There is a cut-out along
the edge through which the affected breast is able hang. Arms are placed above the head
and there are handles on which to grasp. A head support may also be provided that
resembles that of a massage table or chair (Figure 4).\textsuperscript{20} It has been shown to be more
difficult to consistently reproduce proper patient position utilizing a prone setup. When
comparing patient setup errors between prone and supine positions, errors were
consistently larger for the prone position.\textsuperscript{11} While beam on time for prone treatments is
no longer than that for supine, the length of time for each treatment period was longer for
prone. This is believed to be due to the increase in repositioning necessary to obtain the
required accuracy to perform the treatment.\textsuperscript{13}

\textbf{Figure 4.} Prone breast board (A) on treatment couch without patient and (B) with patient
in treatment position.\textsuperscript{20}

Another disadvantage to administering breast irradiation in the prone position is
the inability to adequately treat any necessary lymph nodes. When performing whole-
breast irradiation, it is often difficult to obtain therapeutically sufficient doses to the axillary lymph nodes, regardless of position. For patients who were treated prone, the radiation dose to the axillary and internal mammary nodes were non-therapeutic and substantially lower than doses received in the supine position.\textsuperscript{10}

**Conclusion**

With the continued prevalence of breast cancer throughout the world, it is crucial that treatments stay up-to-date and are providing the best possible outcomes. In the future, radiation therapy will continue to be a major aspect of treatment for breast cancer. Due to the high doses of radiation, it is imperative that the most effective means of delivering the dose is employed. For most women, this can be achieved through the use of a prone treatment position in which a great deal of the non-target tissues can be avoided. More often, the advantages of this position will outweigh the disadvantages. There are certain cases in which a supine position is more appropriate, and this position should always be considered in conjunction with the prone position during treatment planning. Each case is unique and will always require a full examination of options in order to determine the best course of treatment for each individual.
AMA References


