SHORT COMMUNICATION

Comparative Evaluation of Wedge and Field-in-Field Methods in Minimizing Brachial Plexus Radiation Dose for Breast Cancer Patients Undergoing Radiotherapy

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Abstract

Purpose: Brachial plexopathy in breast cancer patients undergoing radiation therapy is an important side effect. The primary objective of this study was to compare the dose of two different treatment methods, the wedge and field-in-field methods, in breast cancer patients undergoing radiotherapy. Specifically, the study aimed to evaluate the impact of these methods on the radiation dose received by the brachial plexus, a critical organ at risk in breast cancer treatment.

Materials and Methods: The study involved 100 breast cancer patients who underwent 25 radiation therapy fractions. The total radiation dose delivered throughout the therapy was 50 Gy, with 2 Gy per fraction.

Results: The mean of maximum dose delivered to the brachial plexus was 5302.18-±2.8 cGy in the wedge group, and 5242.5 ±1.37cGy in the field-in-field group. Although the field-in-field method appeared to be less risky, statistically there was no significant difference between the two methods ($P > 0.05$). Additionally, the mean dose delivered using the wedge method was 4169.98 ±5.33cGy, while the field-in-field method had a mean dose of 4351.9±4.65 cGy and their difference was not statistically significant ($P > 0.05$).

Conclusion: It must be noted that even though the field-in-field technique decreased radiation exposure to the brachial plexus more than the wedge technique, further studies are still needed to determine the practical significance of these findings.

Keywords: Breast Cancer; Radiation Therapy; Wedge; Field-in-Field; Brachial Plexus.

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1. Introduction

There is no doubt that breast cancer is a widespread malignancy worldwide, as it is one of the leading causes of cancer-related death in women [1]. As a result of the availability of multiple treatment options and improvements in early detection techniques, breast cancer patients now have a considerably higher chance of surviving [2]. Radiation Therapy (RT) is an essential component of these treatment options, contributing to limiting localized complications and minimizing recurrence risk [3]. Breast cancer management includes techniques such as regional nodal and whole breast irradiation [4]. Despite the considerable advantages of adjuvant radiation therapy, there are also risks associated with it [5]. Radiation-Induced Brachial Plexopathy (RIBP) is an adverse effect resulting from radiation exposure, bringing about neurological disorders in the brachial plexus of the involved limb [6]. There is a wide variation in the incidence rate of RIBP within breast cancer patients undergoing comprehensive adjuvant radiation therapy [7]. The percentage ranges from 2% to 30%. RIBP has a prolonged latency between exposure to radiation and the onset of symptoms, which indicates an underestimation of the valid rate of RIBP [8]. RIBP's precise pathophysiological processes still need to be fully elucidated, even though several factors have been suggested as underlying the condition [9]. Numerous mechanisms have been proposed to influence the symptoms caused by radiation to the brachial plexus, such as demyelination, fibrosis, DNA damage, and injury to the endothelial cells of the blood vessels [10, 11]. A crucial part of managing RIBP is early detection and employing proper management plans since the condition can negatively affect patients' quality of life [12].

In the context of radiotherapy for breast cancer treatment, the wedge method and field-in-field therapy are two different approaches used to deliver radiation to the target area [13]. These techniques are aimed at optimizing the balance between the effectiveness of the treatment and the potential side effects on critical organs. The wedge method involves the use of a wedge-shaped device made of a material with varying thickness properties. This device is placed in the radiation beam path, which helps to shape the dose distribution by attenuating the radiation in certain areas [14]. The wedge can be positioned at different angles to achieve the desired dose distribution and minimize the dose to nearby healthy tissues. On the other hand, field-in-field therapy, also known as Intensity-Modulated Radiation Therapy (IMRT), is a more advanced technique that uses multiple small radiation fields with varying intensities [15]. By adjusting the intensity of each field and their overlapping patterns, the dose distribution can be shaped precisely to conform to the target area, while sparing nearby critical structures.

The primary objective of the study mentioned was to compare the dose of these two treatment methods: the wedge method and field-in-field therapy. Specifically, the study aimed to evaluate the impact of these methods on the radiation dose received by the brachial plexus.

2. Materials and Methods

2.1. Ethical Approval

The research team ensured that all necessary steps were taken to protect the rights, welfare, and privacy of the participating breast cancer patients. Strict confidentiality measures were implemented to safeguard the participants' personal and medical information. The study was conducted in accordance with the ethical guidelines outlined in the Declaration of Helsinki and adhered to applicable local, national, and international regulations.

2.2. Patients

From 2018 to 2021, one hundred breast cancer patients participated in the survey. These patients underwent a standardized treatment protocol consisting of 25 radiation therapy fractions, including the supraclavicular and tangential fields. Each treatment fraction delivered a dose of 2 Gy, resulting in a cumulative radiation dose of 50 Gy throughout the therapy. The RT planning is based on transverse Computed Tomography (CT) scans covering the region from the 6th cervical vertebra to the middle part of the abdomen. CT slice thickness was 5 mm. CT simulation was conducted while the patient was in the supine position, with both arms extended above the head and immobilized using a breast board. The clinical target volume, both lungs and the heart, the brachial plexus, and the spinal cord were delineated in the planning CT images. Treatment planning and dose calculation were performed using the Eclipse-treatment planning (Version 15.5) system applying a

AAA algorithm. The beam arrangement consisted of three half-beams with two tangential beams covering the caudal part of the target volume and one anterior field. The study also included 10 patients who received radiation therapy through the posterior field.

2.3. Groups

The patients were divided into two groups to compare the dose of two different methods: the wedge method and the field-in-field process. The first group consisted of 50 patients who were treated using the wedge method. The second group included 50 patients who received treatment using the field-in-field method. The two groups were matched in terms of field number, treatment staging, and BMI.

2.4. Statistical Analysis

Statistical analysis of the data on maximum and mean doses in both groups was conducted using the T-test (SPSS ® Software version 16). Odds Ratios (ORs) and 95% Confidence Intervals (CIs) are reported. P values of 0.05 or less were considered to indicate statistical significance.

3. Results

For the wedge group, the mean of maximum dose delivered to the brachial plexus was 5302.18-±2.8 cGy, while, for the field-in-field method group, the mean of maximum dose was 5242.5 ±1.37cGy. However, the field-in-field approach looked less risky, statistically; it was not significant (P>0.05). Furthermore, the wedge method delivered a mean dose of 4169.98 ±5.33cGy, while the field-in-field process had a mean of 4351.9±4.65 cGy; however, this difference was not statistically significant (P > 0.05). The study also included 10 patients who received radiation therapy through the posterior field. The mean of maximum dose delivered in this posterior field was 5700m ±2.57 cGy, which represents a significantly higher dose and carries a greater risk for potential complications.

4. Discussion

Breast-conserving surgery and postoperative radiotherapy are the gold treatments for breast cancer [16]. Reducing the complications of radiotherapy is important since most patients with breast cancer have long-term survival [17]. A noteworthy aspect of the field-in-field method used in this research was that it minimized radiation exposure to the brachial plexus versus the wedge method. This finding did not achieve statistical significance. However, its clinical importance and potential ramifications for patient care should be addressed. Dose-volume histogram analysis indicated that the wedge technique delivered higher radiation doses to the brachial plexus when compared to the field-in-field method.

There is serious concern about the safety of the posterior field, given that the maximum dose delivered reached 5700 ±2.57 cGy. Significant risks are associated with such high dosage levels and deserve careful consideration and evaluation. A closer examination of the potential long-term consequences, immediate side effects, and overall impact on patients' well-being is required to evaluate the potential dangers of this treatment modality. We cannot overstate the importance of examining a larger statistical population of patients who underwent posterior radiation field. Considering the potential dangers associated with the maximum dose of 5700 ± 2.57cGy, a comprehensive evaluation is necessary to assess the immediate and long-term consequences. Data-driven analyses are critical for improving our understanding of breast cancer treatment and ensuring patient safety.

In a recent systematic review and meta-analysis, Yan *et al.* examined the incidence of RIBP and its correlation with radiotherapy doses to the brachial plexus [18]. Twenty-five studies were analyzed, and each Gy increase in the maximum amount (D_{max}) significantly increased the risk of RIBP. Meta-analysis results support the authors' assertion that current brachial plexus restrictions of 60–66 Gy are safe.

In a study conducted by Rudra *et al.*, they assessed the risk of RIBP among breast cancer patients receiving comprehensive adjuvant RT [7]. A retrospective review included 498 patients who received either Conventional Radiotherapy with Three to five fields (CRT) or IMRT. Dose-volume histogram evaluations were conducted on

RIBP occurrence. No statistically significant difference was found between CRT (1.6%) and IMRT (0.4%) attributable to RIBP. IMRT did not increase the risk of RIBP, and no dose volume histogram predictors could be identified.

Further studies with more significant sample sizes are required to gain a more detailed perspective of these treatment techniques' influence on brachial plexus dysfunction. A larger sample population can offer more convincing evidence about variances in radiation exposure levels and their significance in clinical practice, increasing the study's statistical power. The occurrence and intensity of brachial plexopathy must also be investigated through extended follow-up studies in the future. Observed radiation dose fluctuations could harm the outcome of the patient's health, self-reliance, and life quality over an extended period. We must emphasize that this study focused on the dose volume histogram properties of wedge and field-in-field radiotherapy on the brachial plexus of breast cancer patients. Several treatment-related factors and the patient's characteristics may also be affecting brachial plexopathy intensity and progression. To examine these variables concerning treatment outcomes, subsequent studies should determine how they interact.

5. Conclusion

It has been found that the field-in-field technique does not significantly reduce brachial plexus radiation compared to the wedge method. However, it is still necessary to conduct more research to determine whether this technique will be effective clinically. An important objective remains to optimize radiation treatment approaches to minimize brachial plexopathy after radiation therapy. The analysis of dose-volume histograms allows us to improve therapy protocols through a deeper understanding of these figures and to provide better patient care overall.

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