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Review Article

Evaluation of critical organ dosimetry with focus on heart exposure in supine versus prone patient positioning for breast irradiation

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Abstract

Breast cancer (Ca) remains to be the most frequent cancer among females and a leading cause of cancer associated mortality worldwide. Main modalities for management of breast Ca include surgery, Radiation Therapy (RT), and systemic treatments. Diagnosis at earlier stages of breast Ca is increasing with rigorous utilization of screening and raised public awareness. Improvements in therapy contribute to longer life expectancies for patients with breast Ca. In this context, adverse radiation effects are being a more pronounced aspect of breast Ca management recently.

While the adverse effects of irradiation in earlier studies may have led to unfavorable outcomes for some patients with breast Ca, toxicity profile of radiation delivery has been improved with introduction of modernized equipment and contemporary techniques such as Breathing Adapted Radiation Therapy (BART), Image Guided Radiation Therapy (IGRT), Intensity Modulated Radiation Therapy (IMRT) and Adaptive Radiation Therapy (ART). Individualized patient positioning has also been utilized for improved normal tissue sparing while maintaining target coverage. While the conflicting results of cardiac dosimetry among different studies may partly be explained by variations in delineation and treatment techniques between treatment centers, prone positioning may be considered for at least a selected group of breast Ca patients as a viable alternative to supine positioning. Herein, we evaluate critical organ dosimetry with focus on heart exposure in supine versus prone patient positioning for breast irradiation.

Introduction

Breast cancer (Ca) remains to be the most frequent cancer among females and a leading cause of cancer associated mortality worldwide [1-3]. Main modalities for management of breast Ca include surgery, radiation therapy (RT), and systemic treatments. Diagnosis at earlier stages of breast Ca is increasing with rigorous utilization of screening and raised public awareness. Improvements in therapy contribute to longer life expectancies for patients with breast Ca. In this context, adverse radiation effects are being a more pronounced aspect of breast Ca management recently.

RT is typically administered after Breast Conserving Surgery (BCS) or mastectomy particularly for achieving improvement in local control and overall survival in selected patient groups [4-8]. Nevertheless, improvement in overall survival was not achieved in some studies which may partly be explained by radiation induced toxicity particularly in earlier studies [9-11]. An overview of randomized trials of advuvant RT in breast Ca by Cuzick et al. revealed that irradiation could potentially be detrimental in the long term [12]. Cardiac mortality after irradiation was considered to offset the potential benefits of irradiation for some patients suffering from adverse radiation effects [9-14]. While the adverse effects of irradiation in earlier

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studies may have led to unfavorable outcomes for some patients with breast Ca, toxicity profile of radiation delivery has been improved with introduction of modernized equipment and contemporary techniques such as Breathing Adapted Radiation Therapy (BART), Image Guided Radiation Therapy (IGRT), Intensity Modulated Radiation Therapy (IMRT) and Adaptive Radiation Therapy (ART) [15-22]. Individualized patient positioning has also been utilized for improved normal tissue sparing while maintaining target coverage. Herein, we evaluate critical organ dosimetry with focus on heart exposure in supine versus prone patient positioning for breast irradiation.

Critical Organ Dosimetry with Focus on Heart Exposure in Supine versus Prone Patient Positioning for Breast Irradiation. An overwhelming majority of patients receive RT as part of breast conserving therapy primarily to improve local control rates which has been substantiated by high level evidence from metaanalyses [23-25]. Postmastectomy irradiation may also be considered for selected high risk patients to improve treatment outcomes [4-8]. Nevertheless, radiation induced cardiotoxicity resulting in cardiovascular diseases and even mortality has been addressed in a plethora of studies [26-46]. Considering that patients with breast Ca typically survive longer as a result of increased screening and early detection along with more effective local and systemic therapies, quality of life has been regarded as an endpoint of utmost importance. In this context, efforts have been focused on improving the toxicity profile of radiation delivery. Guidelines suggested contouring of the heart in light of validated consensus recommendations to reduce variations in target and critical organ delineation [47-51]. Positioning of patients and immobilization has gained priority with contemporary image guided treatment strategies with minimized margins around the target volumes to account for setup uncertainties. Immobilization and patient positioning are critical aspects of contemporary breast cancer RT, and repoducibility is an important concern. While supine positioning has been traditionally utilized for breast Ca RT, several studies addressed the prone positioning as a viable alternative in selected patients [52-61]. In the study by Speleers et al.assessing supine or prone crawl photon or proton breast and regional lymph node radiation therapy including the internal mammary chain, mean doses to critical organs were found to be generally lower for prone crawl than for supine positions and for proton than for photon plans [52]. Chung et al. reported the Korean first prospective phase II study on the feasibility of prone position in postoperative whole breast RT [53]. They concluded that prone breast RT could be beneficial for a subset of patients with small breasts since it spares critical structures while maintaining target coverage [53]. Saini et al. evaluated critical organ sparing in supine and prone positions with deep inspiration breath hold for left sided breast cancer patients [54]. Prone free breathing and supine deep inspiration breath hold techniques were found to be advantageous for critical organ sparing [54]. Mulliez et al. assessed prone deep inspiration breath hold for cardiac sparing in left sided breast irradiation, and prone deep inspiration breath hold was found to reduce mean heart doses to less than 2 Gray regardless of breast volume [55]. Mulliez et al. compared prone and supine positioning in a randomized setting of hypofractionated whole breast irradiation in another study which concluded that prone positioning could replace supine positioning in patients with large breasts for intensity modulated breast RT [57]. Lymberis et al. prospectively assessed optimal positioning for breast RT [58]. The authors concluded that prone setup decreased the amount of irradiated cardiac volume in vast majority of patients with left sided breast cancer [58]. Formenti et al. addressed prone versus supine positioning for breast cancer RT and prone positioning was found to reduce the amount of irradiated heart volume in majority of left sided breast cancer patients [59]. The patient typically lies on a platform with an aperture in the prone position, and the target breast is displaced from the thorax due to gravitation [62-64]. Lying in prone position typically results in improved expansion of the lungs, which translates into an increased normal lung volume during RT with decreased mean lung doses. Reduced lung doses may be considered as an important benefit of breast RT in the prone position, however, its effect on cardiac doses is less clear. Prone positioning allows for displacement of the breast parenchyma away from the chestwall thereby enabling designation of the radiation portal to include less heart volume. Increased distance between heart and the chestwall by prone positioning may allow for improved cardiac sparing in selected patients. Reduction of cardiac doses with breast RT in prone positioning has been supported by several studies for at least a selected group of patients, with some studies also focusing on optimized normal tissue sparing and target coverage in prone positioning such as improved dose coverage and homogeneity, reduced volumes of overdosage, lower ipsilateral pulmonary and mean left anterior descending artery doses, decreased moist desquamation with lower incidence of dermatitis, edema, pruritus, and pain [52-61]. While the conflicting results of cardiac dosimetry among different studies may partly be explained by variations in delineation and treatment techniques between treatment centers, prone positioning may be considered for at least a selected group of breast Ca patients as a viable alternative to supine positioning. Reproducibility may be considered as a concern for prone positioning, nevertheless, selected groups of patients such as those with pendulous breasts may substantially benefit from this positioning strategy. In this context, we consider that prone positioning may serve as a viable approach for critical organ sparing for atleast a selected subgroup of patients receiving RT for breast cancer.

Conclusions and future perspectives

Radiation oncology discipline is experiencing ever increasing advances with incorporation of modernized equipment and contemporary strategies such as BART, IGRT, IMRT, ART, and state of the art radiosurgical applications which significantly improve the toxicity profile of radiation delivery in the millennium era [15-22,65-100]. Reflections of these advances have been demonstrated as improved critical organ sparing with optimal therapeutic outcomes for patients with breast Ca. Significant achievements have been made in treatment delivery techniques along with improved therapeutic outcomes with a favorable toxicity profile. Prone positioning appears to be beneficial at least for a selected group of patients with

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breast Ca. Improved critical organ sparing with contemporary techniques holds promise for optimized management of breast Ca despite the need for further supporting evidence.

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