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Dosimetry Contribution:

Electron postmastectomy chest wall plus comprehensive nodal irradiation technique using Electron Monte Carlo dose algorithm

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A B S T R A C T

For left-sided postmastectomy patients requiring chest wall plus comprehensive nodal irradiation, sometimes traditional techniques such as partial wide tangents or electron/tangents combination are not feasible due to abnormal chest wall contour or heart position or unusually wide excision scar. We developed electron chest wall irradiation technique using Electron Monte Carlo (EMC) dose algorithm that will achieve heart sparing with acceptable ipsilateral lung dose, minimal contralateral lung, and breast dose. Ten left-sided postmastectomy patients with very challenging anatomy were selected for this dosimetry study. The *en face* electron fields were designed from a single isocenter and gantry angle with different energy beams using different cutouts that matched on the skin. Smaller energy was used in the central thin chest wall part and higher energy in the medial internal mammary nodes (IMN) area, superior part of the thick chest wall, and/or axillary nodal area. The electron fields were matched to the photon supraclavicular field in the superior region. Daily field junctions were used to feather the match lines between all the fields. Electron field dose calculations were done with Monte Carlo. Five patients' chest wall fields were planned with 6/9MeVcombination, 1 with 6/12 MeV, 2 with 9/12 MeV, 1 with 9/16 MeV, and 1 with 6/9/12 MeV. Institutional criteria of prescription dose of 50 Gy for target volumes and normal tissue dose were met with this technique in spite of the challenging anatomy. Mean heart dose averaged 3.0 Gy ± 0.8 Gy. For ipsilateral lung, V20Gy and V5Gy averaged 33.2% ± 4.5% and 64.6% ± 9.6%, respectively. For contralateral lung, V5Gy averaged 5.1% ± 5.0%. For contralateral breast, V5Gy averaged 3.3% ± 3.1%. The electron chest wall irradiation technique using EMC dose algorithm can provide adequate dose coverage to the chest wall, IMNs, and/or axillary nodes while achieving heart sparing with acceptable ipsilateral lung dose, minimal contralateral lung, and breast dose.

Introduction

For node-positive breast cancer patients, postmastectomy radiation therapy (PMRT) has been shown to reduce the risk of breast cancer recurrence and mortality.[1] Treatment

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planning of PMRT often poses technical challenges because the desired treatment plan will need to not only cover the chest wall and nodal volume adequately with acceptable dose inhomogeneity but also meet dose constraints to the lungs, heart, and contralateral breast. A variety of techniques, including partial wide photon tangents and photon/electron combination, were devised to produce plans depending on variations in patient's anatomic features.[2,3] More recently, techniques using intensity-modulated radiation therapy (IMRT) or volumetric-modulated arc therapy (VMAT) and proton therapy were also developed.[4-6]

For left-sided postmastectomy unreconstructed patients requiring chest wall and/or nodal irradiation, sometimes the commonly used partial wide tangents or electron/tangents combination would include an unacceptable amount of lung or heart in the fields due to pectus excavatum chest wall curvature, heart position close to the anterior chest wall, or unusual wide excision scar.[2] Since 1990, conformal, computed tomography-based electron beam therapy has been used to treat the chest wall of postmastectomy patients at the Memorial Sloan-Kettering Cancer Center. Mixed-energy electron beams with customized bolus were used to ensure adequate skin dose and to tailor the prescription dose to the lung chest wall interface using electron pencil beam (EPB) dose algorithms.[7] In 2015, the Memorial Sloan-Kettering Cancer Center adopted the Eclipse Treatment Planning System (Varian Medical Systems, Inc., Palo Alto, CA) and Electron Monte Carlo (EMC) dose algorithm. Clinical plans were recalculated using the EMC dose algorithm. Because of the significant dose difference in lateral scattering and depth penetration due to inhomogeneity or surface curvature from EMC compared with EPB, it was observed that the delivered prescription isodose line usually did not reach beyond the anterior edge of the rib cage including the pectoralis major but not necessarily covering the pectoralis minor. This coverage to the chest wall seemed to be adequate based on our in-house low recurrent rate clinical experience and published data.[3,7,8] We also found that our old EPB planning technique could not be used in Eclipse using EMC to produce plans that meet our clinically established chest wall constraints for target coverage, and heart and lung dose constraints. The old technique relied heavily on layers of custom bolus with very limited electron energy variation for any particular patient. In Eclipse, producing detailed custom bolus was not clinically feasible especially with dose distribution calculated using EMC. In fact, we had to implement quite a different procedure for design of the electron fields and the utilization of custom bolus so that the EMC plan would meet clinical criteria. This technique makes more use of electron fields' different energies and much less use of custom bolus. We are not aware of a published electron chest wall technique for commercially available treatment planning systems using EMC dose algorithm. In this study, we present an electron chest wall irradiation technique using EMC dose algorithm that will provide adequate internal mammary node (IMN), chest wall and/or axillary node coverage while meeting lung constraints and achieving heart sparing.

Methods and Materials

Ten left-sided postmastectomy patients who received radiotherapy using the electron chestwall technique described in reference 7 were selected for this dosimetry study. Target volumes and normal tissues were drawn based on institutional protocols. Prescription dose was 2 Gy per fraction for a total 50 Gy. Dose calculations were done with Eclipse EMC_11031for Electron (EMC calculation options were set to be: Accuracy (Statistical uncertainty) 2, Calculation grid size 0.25 cm) and AAA_11031 for photons.

For a patient with the anatomy shown in Fig. 1A, B, and C, the traditional beam arrangements such as partial wide tangents or IMN tag electron field combined with photon tangents would exceed normal heart or lung dose constraints. We used electron fields that matched on the skin to achieve dose conformity to the chest wall. The *en face* electron fields were designed at extended source-to-surface distance from a single isocenter and gantry angle but with different energy beams using different cutouts. The outside boundary of the cutout followed the wire placed by the physician during simulation based on palpation and clinical assessment of the patient's anatomy. Lower energy was used in the central thin chest wall part and higher energy was used in the medial IMN area, superior part of the thick chest wall, and/or axillary nodal area, as shown in Fig. 1D. Bolus was used for the electron fields to ensure adequate skin dose coverage. For the supraclavicular area, a traditional single oblique photon field was used. Occasionally a posterior axillary boost photon field was also used. The electron fields were matched to the photon supraclavicular field in the superior region. As shown in Fig. 1E, a daily 1-cm feathering of the junction was used between the electron/photon supraclavicular field and junctions of 0.5 cm were used between the electron fields of different energies.

We usually start with the 6 MeV and 9 MeV combination. A base bolus of 0.5 cm is placed across the chest wall to ensure adequate skin dose. For each electron field, a normalization point at the geometric depth of maximum dose from the data table for that energy is created. The normalization point is placed in the middle of the cutout and at least 1.5 cm away from the cutout edge. The geometric depth of the point should include the bolus thickness. We start by assigning 111.1% to that normalization point so that the 100% (prescription) isodose line corresponds to the 90% depth dose traditionally prescribed in electron therapy. With EMC, we observed that normalization to the traditional isodose level