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Case report

Volumetric modulated arc therapy for synchronous bilateral whole breast irradiation – A case study

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ABSTRACT

Purpose: The treatment planning of bilateral breast irradiation (BBI) is a challenging task. The overlapping of tangential fields is usually unavoidable without compromising the target coverage. The purpose of this study was to investigate the technical feasibility and benefits of a single isocentre volumetric modulated arc therapy (VMAT) in BBI.
Methods and materials: Two women with bilateral breast cancer were included in this case study. The first patient (Pat#1) underwent a bilateral breast-conserving surgery and sentinel lymph node biopsy. The second patient (Pat#2) underwent a bilateral ablation and axillary lymph node dissection. Planning target volumes (PTV) and organs at risk were delineated on CT images. VMAT plans were created with four (two for both sides, Pat#1) or two (one for each breast, Pat#2) separate VMAT fields. Subsequently, traditional tangential field plans were generated for each patient and the dosimetric parameters were compared.
Results: The treatment times of the patients with VMAT were less than 15 min with daily CBCT imaging. When compared to the standard tangential field technique, the VMAT plans improved the PTV dose coverage and dose homogeneity with improved sparing of lungs and heart. With traditional field arrangement, the overlapping of the tangential fields was inevitable without significantly compromising the target coverage, whereas with VMAT the hotspots were avoided. The patients were treated with the VMAT technique and no acute skin toxicity was observed with either of the patients.
Conclusions: A single isocentre VMAT technique has been implemented clinically for BBI. With the VMAT techniques, the dose delivery was quick and the hotspots in the field overlapping areas were avoided. The PTV dose coverage was superior in VMAT plans when compared with conventional tangential technique plans.

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1. Introduction

Breast cancer is the leading cancer site in women worldwide with an estimated 1.4 million new cases diagnosed every year.[1] Synchronous bilateral breast cancer (BBC) is very uncommon, the latest estimate for the incidence being only 2.1%.[2] Although the number of cases of BBC is rare in one treatment centre the overall BBC patient population grows approximately to 30,000 new cases a year worldwide. Compared to unilateral breast cancer radiotherapy, the treatment planning and dose delivery of BBC is very complex and time consuming. One of the standard treatment techniques for BBC is to use a tangential field configuration.[3,4] With the traditional tangential field-arrangement either a significant amount of beam overlap is needed or, alternatively, under-dosage of some parts of the PTV has to be accepted with some patient groups. The drawbacks of the conventional tangential technique often also include inhomogeneous dose distribution with hotspots or inadequate coverage of the target structure, especially with obese patients, or the inability to reduce the high dose volumes of the heart and ipsilateral lung. The dose inhomogeneities have been correlated with radiation-induced dermatitis, acute desquamation and late soft-tissue fibrosis and the quality of life of the treated patients has been reported to decline by these physical symptoms.[5–8]

The use of a volumetric modulated arc therapy (VMAT) has steadily increased in external beam radiotherapy. In VMAT the radiation dose is delivered by continuously varying gantry speed, field shape and dose rate. In the literature, there are only a few reports that have studied the modulated treatment techniques for BBC. These studies are mainly treatment planning and dosimetric studies with an intensity modulated radiotherapy (IMRT)[9] or a VMAT technique[10] and the actual radiotherapy treatments have been carried out with a conventional technique. Intensity modulated proton[11] and electron arc[12] treatment planning studies have also been investigated for BBI. In our knowledge, the only reported case about BBC patients treated with a modulated technique is a study of Cendales et al.[13] where they used Helical Tomotherapy for complex treatment volumes. Unfortunately, however, in that particular study it was not specified how the treatment plans were accomplished and more specific information about the treatment planning for the bilateral breast cases were not given. In our knowledge, this is the first report to use a VMAT technique for bilateral breast irradiation (BBI) to enhance dose distributions within the irradiated volume. In the present study, we report two cases of BBC patients treated with a single isocentric VMAT technique.

2. Case reports

2.1. *Patient histories and diagnoses*

Two different patient cases are reported. The first case (Pat#1), was a 67-year-old female with bilateral ductal breast carcinoma. She underwent bilateral breast-conserving surgery and sentinel lymph node biopsy (right breast: T2N1M0 stage IIA, left breast: T1aN0M0 stage I). The second patient (Pat#2) was a 71-year-old female with bilateral multifocal lobular breast carcinoma. She underwent bilateral ablation and axillary lymph node dissection (right breast: T2N2M0 stage IIIA, left breast: T2N2M0 stage IIIA). With both patients, chemotherapy consisted of three cycles of docetaxel plus three cycles of cyclophosphamide, epirubicin and fluorouracil (CEF).

2.2. *Imaging and treatment planning*

Both patients were imaged supine with a CT scanner (Toshiba Aquilion LB, Toshiba Medical Systems Co., Tochigi, Japan) in treatment position with a slice thickness of 2 mm. Planning target volumes (PTV) of the left and right breast were delineated on the CT data according to the department guidelines. With Pat#1 the PTV included the glandular breast tissue and the lower part of the fossa axillae. With Pat#2 the chest wall and the regional lymph node areas were included into the PTV. Atlas-based auto-segmentation software (ABAS, Elekta AB, Stockholm, Sweden) was used to delineate the critical structures which were verified by the user and manually corrected if necessary. The critical structures delineated were both lungs, heart, left anterior descending (LAD) coronary artery, thyroid gland, shoulder joints and oesophagus.

The VMAT plans were generated on Monaco® treatment planning system (TPS) (version 3.30.01, Elekta AB) for Elekta Infinity linear accelerator with Agility MLC. The VMAT plans were created with four (two for both breast, Pat#1) or two (one for each breast, Pat#2) separate VMAT fields with an energy of 6 MV. The field arrangements are shown in Fig. 1. The plans were optimised simultaneously for all arcs with a single isocentre located below sternum (Fig. 1). Treatment plans were optimised with a maximum number of control points of 140, a minimum segment width of 1.0 cm and with high fluence smoothing. An autoflash margin of 1.5 cm and surface margin of 0.5 cm were used in the optimisation (e.g. the inner margin from the skin surface that was excluded from the optimisation). A standard deviation of 1% was used in Monte Carlo (MC) dose calculation with a dose grid of 3.0 mm. The prescription dose (50 Gy/25 fr) was normalised to the mean dose of the PTV (excluding a 5 mm margin from the skin surface).

For comparative reasons, a traditional field-in-field (FinF) tangential technique, which has become a standard technique in breast cancer radiotherapy,[14] was used to create a treatment plan with the identical CT data and structure sets. In FinF, planning subfields are created by manually moving the MLC positions to enhance the dose homogeneity.[15] The FinF plans were generated in Oncentra® TPS (version 4.3.0.410, Elekta AB) with an identical single isocentre. Dose distributions were calculated with collapsed cone convolution (CCC) algorithm with a dose grid of 3.0 mm.

2.3. *Treatment verification*

The calculated dose distributions of the VMAT plans were verified by delivering the treatment plans to a MatriXX ionisation chamber array with a MultiCube phantom (IBA, Schwarzenbruck, Germany). The gantry angle corrections were performed and the measured coronal planes were compared against the calculated dose distributions (Fig. 2). OmniProI'mRT (v1.7.0021, IBA) software was used to analyse