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Research Paper

Heart dose comparison between hybrid-beams and photon-beam VMAT for breast cancer

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ABSTRACT:
Purpose/Objective(s): *The aim of this study was to compare heart dose performance between hybrid-beams (electron-photon) and photon-beam VMAT techniques for left breast irradiation after mastectomy. Because, late toxicity is a major problem in long-term survivors and significantly affects quality of life.*
Materials/Methods: *A retrospective analysis was performed on 14 left breast cancer patients with partial VMAT technique, which consisted single isocentre. Patients received 50Gy in 25 fractions to chest wall, supraclavicular nodal region, axillar nodal region and internal mamary nodal region. Then, hybrid-beams partial VMAT technique was performed for these patients. 1/4 prescribe dose was performed with 6 to 8 MeV electron-beam and 3/4 prescribe dose was performed with 6 MV photon-beam partial VMAT technique while using bias dose property which considers base electron-beam plan doses for PTV(chest wall). The same PTV coverage obtained for both techniques.*
Results: *We determined average 275.3±47 and 320.7±58 cGy heart mean doses, 243.5±58 and 291.1±51 cc V2 Gy heart doses with hybrid-beams and photon-beam VMAT techniques. The low dose volume reduced with hybrid-beams VMAT technique for heart. The results showed good and homogenous target coverage while sparing heart. Average 95±1% and 98±1% agreements determined between planned and delivered dose using 3%-3mm γ analysis for VMAT technique and point dose for hybrid-beams technique.*
Conclusion: *The lateral electron beams in the thoracic region that do not irradiate the heart and contralateral lung. Linac-based hybrid-beams VMAT is a good treatment technique for reducing low dose volume of heart and late toxicity possibilities. Herein, special methods adopted for left breast irradiation. Using this treatment method, further research is warranted to get clinical results.*
KEYWORDS: *Hybrid-beams, VMAT, Breast Cancer*
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I. INTRODUCTION

Breast cancer is the leading cancer among women worldwide.[1] For many women with early-stage breast cancer, mastectomy can remove any detectable macroscopic disease, but some tumour foci might remain in locoregional tissue (ie, chest wall or regional lymph nodes) that could, if untreated, lead to recurrence of the disease and death from breast cancer. Radiotherapy is an effective treatment technique for managing breast cancer. But, late toxicity is a major problem in long-term survivors and significantly affects quality of life. The excess risk is linearly dependent on mean heart dose at a rate of 15.5% per Gy within 10 years of RT and 7.4% per Gy within 20 years.[2] Post mastectomy radiotherapy entails challenges in breast treatment due to thin targets next to lungs, heart, and controlateral breast. Several studies have reported that advanced treatment techniques like intensity modulated radiotherapy (IMRT) and volumetric modulated arc therapy (VMAT) improve the dose homogeneity and plan quality instead of conventional tangential techniques with wedges.[3-8] However, these techniques have been reported to increase the volume of organs at risk (OARs) receiving a low dose and require higher monitor units (MU), thereby increasing the risk of secondary cancers.9 Several studies have introduced the concept of hybrid IMRT that combines conventional fields with IMRT fields for whole breast RT.[10-12] But, the hybrid technique for breast irradiation after mastectomy has reported to combine just photon beams with different treatment modalities.

The purpose of this study was to combine Hybrid-beams with electron and photon for VMAT technique, also we compared heart dose performance between photon VMAT and hybrid-beams (electronphoton) VMAT techniques for left breast irradiation after mastectomy.

II. MATERIAL AND METHODS

A retrospective analysis was performed on 14 left breast cancer patients. Patients were immobilized in supine position using a breast board. All scans were performed with a 20 slices PET/CT scanner (Siemens biograph mCT) with 3 mm slice thickness. A monte carlo algorithm based Monaco® 5.11.02 (Elekta AB, Stockholm) treatment planning system (TPS) were performed for electron and photon accurate dose calculation, treatment optimization, leaf sequencing and plan analysis. Patients received 50 Gy in 25 fractions to chest wall, supraclavicular nodal region, axillar nodal region and internal mamary nodal region with two symmetrical partial 80° arcs for VMAT technique which consisted single isocentre in Versa HD^{TM} (Elekta AB, Stockholm) linear accelereator. Then, hybrid-beams partial VMAT technique was performed for these patients while using open field 20x20 cm^2 electron-beam and photon-beam partial arcs. 1/4 prescribe dose was performed with 6 to 8 MeV electron-beam and 3/4 prescribe dose was performed with 6MV photon-beam partial VMAT technique while using bias dose property which considers base electron-beam plan doses for PTV(chest wall). All plans achieved expected clinical targets coverage (D95% $\geq$ 47.5 Gy) for both techniques. Pre-treatment patient specific quality assurance was performed using a 2D-array of ionization detectors which was MatriXX Evolution (IBA, Shcwarzenburg) with gantry holder and ppc40 (IBA, Shcwarzenburg) paralel plate ion chamber.

III. RESULTS

The low dose volume reduced with hybrid-beams VMAT technique for heart mean and V2 Gy heart doses, left lung V20 Gy volume received similar percentage for both techniques listed in Table 1. Average heart mean and V2 Gy doses reduced 14.2% and 16.4% with hybrid-beams VMAT technique. Comparative 2 Gy and 10 Gy isodose distributions in photon-beam VMAT and hybrid-beams (electron-photon) VMAT plans are shown in Figure 1. The results showed good and homogenous target coverage while sparing heart. Average 95±1%and 98±1% agreements determined between planned and delivered dose using 3%-3mm γ analysis for VMAT technique and point dose for hybrid-beams technique.

Table 1. Dosimetric parameters for critical organs generated with photon-beam VMAT and hybrid-beams (electron-photon) VMAT techniques.

	Heart mean (cGy)		**V2 Gy Heart (cc)**		**V20 Gy Left Lung (%)**	
	Hybrid-Beams	Photon-Beam	Hybrid-Beams	Photon-Beam	Hybrid-Beams	Photon-Beam
1	304.6	370.2	370.0	406.2	22.4	24.7
2	338.4	352.7	214.2	277.4	23.4	20.9
3	282.6	304.5	218.0	267.6	20.7	19.1
4	345.9	415.9	267.0	334.2	19.7	17.8
5	241.4	278.2	194.5	234.1	19.6	17.0
6	310.4	400.9	317.3	328.9	22.0	20.0
7	243.4	354.4	251.1	302.2	20.6	23.1
8	215.8	250.4	205.4	263.8	16.0	18.3
9	169.2	192.6	122.0	180.7	15.6	11.7
10	299.5	323.9	269.3	317.7	23.2	21.5
11	280.4	310.9	260.4	295.6	22.2	20.8
12	270.6	320.5	240.8	285.8	20.8	20.4
13	260.8	305.4	230.7	284.6	20.2	19.8
14	290.8	314.6	248.8	296.4	21.2	20.8
Mean	**275.3**	**320.7**	**243.5**	**291.1**	**20.5**	**19.7**
±SD	**47.4**	**58.1**	**57.7**	**51.4**	**2.3**	**3.0**

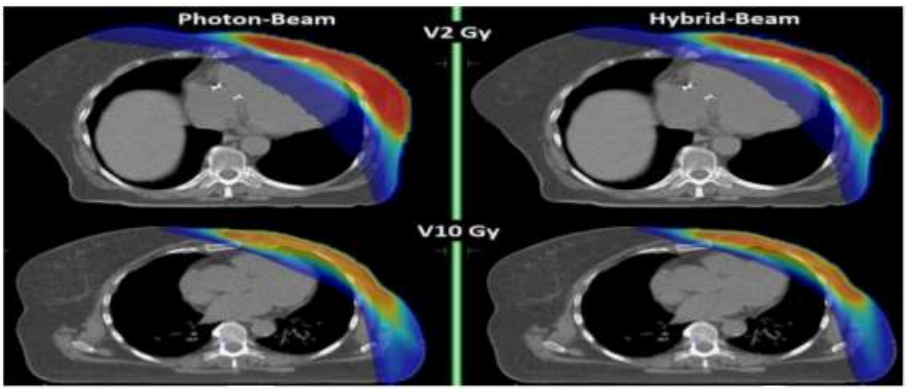

Figure 1. Comparative 2 Gy and 10 Gy isodose distributions in photon-beam VMAT and hybrid-beams (electron-photon) VMAT plans.

IV. CONCLUSION

The lateral electron beams in the thoracic region that do not irradiate the heart and contralateral lung. The combination of VMAT and electron fields decreased normal tissue integral dose compared with photon only VMAT plans. The main goal of the hybrid-beams VMAT plan is to spare heart, and to avoid long-term complications (heart disease) and radiation induced secondary malignancies, without compromising on PTV dosimetric parameters. Darby et al.[2] reported that 1 Gy added to the mean heart dose could increase the rate of ischemic heart disease by 7.4%, regardless of the threshold dose. A dose response relationship exists forpredictor of cardiac dysfunction at higher doses (≥30 Gy). It has been reported that the V25 Gy of heart should be limited to less than 10%.13 Also, there is a relationship between low-radiation doses (~5 Gy) and cardiac mortality.[14-15] Linac-based hybrid-beams VMAT is a good treatment technique for reducing especially low dose volume of heart and late toxicity possibilities. Rosca[16] concluded that a mixed electron+photon planning technique (E + IMRT) can decrease the normal tissue integral dose to patient compared to a photon-only IMRT plan for ten brain cases, two lung, a thyroid, an abdominal, and a parotid case. Our results were similar to present study for hybrid-beams technique. Herein, special methods adopted for left breast irradiation after mastectomy. Using this treatment method, further research is warranted to get clinical results.

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