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Comparison of Helical Tomotherapy and Direct Tomotherapy in Bilateral Whole Breast Irradiation in a Case of Bilateral Synchronous Grade 1 and Stage 1 Breast Cancer

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Patient: Female, 60
Final Diagnosis: Complete remission
Symptoms: None
Medication: —
Clinical Procedure: Radiotherapy
Specialty: Oncology

Objective: Rare disease

Background: Synchronous bilateral breast cancer is rare. A case is presented where whole breast irradiation (WBI) was planned after breast conserving surgery in a patient with synchronous bilateral breast cancer. A comparison was made between the feasibility of helical tomotherapy and direct tomotherapy.

Case Report: A 60-year-old woman was found to have bilateral breast nodules on routine mammographic screening, resulting in bilateral lumpectomy and sentinel lymph node biopsy. Histopathology showed a 6 mm diameter invasive ductal carcinoma in the right breast (Grade 1, hormone receptor positive, HER2 negative) and an 8mm diameter tubular carcinoma in the left breast (Grade 1, hormone receptor positive, HER2 negative). Lymph node biopsy and histology, chest X-ray, abdominal ultrasound scan, and bone scintigraphy were negative for metastases (both tumors were Stage 1). Adjuvant therapy with commenced with anastrozole, but no chemotherapy was given. Clinical target volumes (CTVs) were contoured on computed tomography (CT) images. For planning target volumes (PTVs), CTVs were expanded by 1 cm in all directions, except for the medial 5 mm. Since dose constraints to organs at risk (OARs) were beyond established limits, CTVs were expanded by 5 mm. For PTVs, OAR doses and homogeneity indices for helical tomotherapy and direct tomotherapy were compared. Helical tomotherapy provided better target volume coverage and OAR sparing than direct tomotherapy.

Conclusions: In a case of bilateral synchronous Stage 1 and Grade 1 breast cancer, helical tomotherapy appeared more suitable than direct tomotherapy.

MeSH Keywords: Breast • Breast Neoplasms • Radiotherapy, Intensity-Modulated

Full-text PDF: https://www.amjcaserep.com/abstract/index/idArt/905245

Background

Synchronous bilateral breast cancer is rare and represents between 0.4–2.8% of cases of breast cancer and usually requires whole breast irradiation (WBI) following breast-conserving surgery (BCS) [1]. Because of the large target area for bilateral breast irradiation, difficulty in achieving homogeneous dose distribution in target volumes irradiated, and exposure of organs at risk (OARs), such as the heart and lungs, to high-dose irradiation, bilateral WBI is a complex treatment for which advanced techniques such as tomotherapy may be suitable.

In this case report, we present a rare case of bilateral synchronous Grade 1 and Stage 1 breast cancer in a 60-year-old woman, detected during routine breast screening mammography and compare the dosimetric results of helical tomotherapy and direct tomotherapy for bilateral WBI following BCS.

Case Report

Presentation, breast cancer diagnosis, and staging

A 60-year-old woman was found to have bilateral breast nodules on routine mammographic screening. Bilateral lumpectomy and sentinel lymph node biopsy were performed. Histopathology showed a 6 mm diameter invasive ductal carcinoma in the right breast (Grade 1, hormone receptor positive, HER2 negative, 20% proliferation index) and an 8mm diameter tubular carcinoma in the left breast (Grade 1, hormone receptor positive, HER2 negative, 5% proliferation index). For both tumors, resection margins were tumor-free. Lymph node biopsy and histology, chest X-ray, abdominal ultrasound scan, and bone scintigraphy were negative for metastases, and both tumors were staged as Stage 1. The patient's recovery from surgery was uneventful. Adjuvant therapy with commenced with anastrozole, but no chemotherapy was given.

Radiotherapy

With the patient supine in the treatment position, computed tomography (CT) images without contrast medium were acquired from lung apex to diaphragm. Radiopaque landmarks identified palpable glands. CT scans were transmitted to the treatment planning system (TPS) (Pinnacle3 v9.8). Breast volumes were 737.18 cc (right) and 695.01 cc (left). Clinical target volumes (CTVs) for each whole breast, up to 5 mm below the skin surface, were contoured. For planning target volumes (PTVs), CTVs were expanded 1 cm in all directions, except for the medial aspect, which was expanded by 5 mm. PTV margin evaluations were generated by contracting the PTVs by 5 mm below the skin surface. The heart and spinal cord were contoured manually, and the lungs were contoured automatically. The remaining volume at risk (RVR) was defined as the imaged volume within the patient, minus the delineated OARs and PTVs, according to the International Committee on Radiation Units and Measurements (ICRU) (*https://www.icru.org*).

CT data were transferred to the tomotherapy planning workstation to generate helical tomotherapy and direct tomotherapy treatment plans. Helical tomotherapy treatment plans were generated and optimized using TomoDirect™ (TD) (Accuray Inc., Sunnyvale, CA, USA). Helical tomotherapy plan parameters were: 5.02 cm field width (FW), 0.287 pitch, and a modulation factor (MF) of 3. The heart, spinal cord, and both lungs were spared by using directional blocks placed at these sites.

The direct tomotherapy plan was based on the intensity-modulated radiotherapy (IMRT) technique, with ten beams used for the breast PTV margin evaluation. Four flash beams compensated for intra-fraction motion. The field width (FW), pitch, and modulation factor (MF) were set at 5.02 cm, 0.40 cm, and 3.5 cm, respectively.

The radiation dose given was 42.4 Gy in 16 fractions to each PTV margin evaluation. PTV and OAR doses, and homogeneity indices (HIs), calculated as HI=[(D2%–D98%)/D50%], were compared. Minimum (D98%, D90%, D95%) and maximum (D2%, V107%) PTV dose parameters, D50% and D_{mean} were evaluated. D_{mean}, D2%, and specific volume indices were evaluated for OARs. Remaining volume at risk (RVR) of 100% indicated high doses outside targets and contoured OARs.

Helical tomotherapy provided better PTV margin evaluation coverage than direct tomotherapy, with higher D90%, D95%, D98% and D_{mean}. No hot spots were observed with either technique. Helical tomotherapy provided a lower homogeneity index (HI) (Table 1). Helical tomotherapy and direct tomotherapy provided similar dosimetric results for OARs, but the left lung V4Gy and all spinal cord parameters were improved with direct tomotherapy. Helical tomotherapy was better for RVR V100%. No hot spots were produced outside targets (Table 2). The 5 mm clinical target volume (CTV) expansion lowered lung and heart doses without compromising PTV coverage (Tables 1, 2).

Since helical tomotherapy with 5 mm expansion provided better PTV margin evaluation coverage and spared the OARs more than direct tomotherapy, and was used to treat the patient. She suffered no acute toxicity and after 18 months of follow-up, had no recurrence of her breast cancers, and no late effects of radiation treatment.

Discussion

To our knowledge two previously published studies have reported helical tomotherapy dosimetric results in a small series

Table 1. Planning target volume (PTV) of the right and left evaluated dosimetry for helical tomotherapy (HT) and direct tomotherapy (DT) with 1 cm and 0.5 cm expansion.

	HT PTV right eval		DT PTV right eval		HT PTV left eval		DT PTV left eval	
	1 cm expansion	0.5 cm expansion	1 cm expansion	0.5 cm expansion	1 cm expansion	0.5 cm expansion	1 cm expansion	0.5 cm expansion
D90%	41.7 Gy	41.4 Gy	39.9 Gy	41.4 Gy	41.6 Gy	41.4 Gy	40.6 Gy	40.7 Gy
D95%	41.4 Gy	40.8 Gy	38.6 Gy	40.8 Gy	41.3 Gy	41.1 Gy	39.6 Gy	39.8 Gy
D98%	41.1 Gy	40.1 Gy	36.6 Gy	39.4 Gy	40.9 Gy	40.1 Gy	37.8 Gy	37.0 Gy
D2%	43.6 Gy	43.8 Gy	43.7 Gy	43.3 Gy	43.7 Gy	44.1 Gy	43.8 Gy	43.6 Gy
D_{mean}	42.4 Gy	42.3 Gy	41.9 Gy	42.1 Gy	42.3 Gy	42.4 Gy	42.1 Gy	42.0 Gy
HI	0.06	0.09	0.17	0.10	0.07	0.10	0.14	0.16

HT – helical tomotherapy; DT – direct tomotherapy; PTV right evaluation: – planning target volume evaluation for the right breast; PTV left evaluation – planning target volume evaluation for left breast; HI – homogeneity index.

Table 2. Organ at risk (OAR) dosimetry for helical tomotherapy (HT) and direct tomotherapy (DT) with 1 cm and 0.5 cm.

	Constraints	HT (1 cm expansion)	DT (1 cm expansion)	HT (5 mm expansion)	DT (5 mm expansion)
Right Lung					
V4 Gy	<50%	76.1%	75.5%	42.5%	53.7%
V8 Gy	<35%	42.5%	41.8%	21.7%	39.7%
V16 Gy	<15%	19.2%	22.1%	14.4%	20.8%
D_{mean}		10.9 Gy	10.9 Gy	7.7 Gy	10.1 Gy
D2%		39.2 Gy	37.1 Gy	34.7 Gy	37.8 Gy
Left Lung					
V4 Gy	<50%	80.7%	63.9%	42.0%	52.1%
V8 Gy	<35%	44.8%	42.1%	23.2%	33.4%
V16 Gy	<15%	19.1%	20.1%	13.0%	14.9%
D_{mean}		11.1 Gy	11.1 Gy	7.3 Gy	8.7 Gy
D2%		39.1 Gy	40.7 Gy	32.2 Gy	38.1 Gy
Heart					
D_{mean}	4 Gy	7.5 Gy	7.9 Gy	3.5 Gy	6.0 Gy
D2%		27.2 Gy	27.1 Gy	13.3 Gy	20.7 Gy
Spinal Cord					
D_{mean}		3.7 Gy	2.6 Gy	1.9 Gy	1.7 Gy
D2%	<20 Gy	7.6 Gy	4.1 Gy	3.1 Gy	3.3 Gy
RVR					
V100%		0% (0cc)	0.008% (0.46cc)	0% (0cc)	0.341% (32.18cc)

HT – helical tomotherapy; DT – direct tomotherapy; RVR – remaining volume at risk.

of bilateral breast cancer patients after breast-conserving surgery (BCS) or mastectomy [2,3]. In a series of 14 patients with bilateral breast cancer, Ekici and colleagues reported that helical tomotherapy was well-tolerated, with high homogeneity and coverage indexes and low irradiation doses to the lungs and heart [3]. These findings were supported by the published study of Wadasadawala and colleagues who showed that helical tomotherapy provided better target coverage and a lower homogeneity index (HI) than direct tomotherapy, supporting its use for these patients [2].

Protecting the heart from the effects of irradiation in patients with cancer of the left breast and keeping the radiation dose as low as possible is critical in whole breast irradiation (WBI) planning [4], given the risks linked to adjuvant systemic treatments [5]. In our case, helical tomotherapy with a 5 mm expansion provided a lower mean heart radiation dose which Wadasadawala et al. achieved with direct tomotherapy [2]. The discrepancy in direct tomotherapy results might have been due to using two or four fields rather than the five fields that we used.

Preventing radiation-induced lung toxicity is particularly crucial with bilateral WBI. Even though Liem and colleagues reported that there are no recommended dose constraints for low dose levels [6], good predictors of pneumonitis with conventional fractionation (50 Gy in 25 fractions) are V20Gy under 30% [7] and V5Gy under 75% [8]. Since we used a hypofractionated schedule, V4Gy and V16Gy were considered as equivalents to V5Gy and V20Gy. The best results were achieved with helical tomotherapy and a 5 mm expansion.

However, helical tomotherapy delivered larger low-dose volumes (V5Gy) to the organs at risk (OARs), as multiple beams transverse through normal tissue due to rotation. Despite fixed angles, direct tomotherapy is similar to helical tomotherapy, because once multiple beams leave the target, some pass through adjacent OARs, resulting in low dose exposure. A further problem with helical tomotherapy and direct tomotherapy is dose fall-off caudally and cranially which becomes more marked as the field widens [3,7]. Options for counteracting dose fall-off are to consider the jaw as an OAR and apply a protective directional block or use narrow field widths, but this may be associated with longer treatment times. Treatment times are always longer with helical tomotherapy compared with conventional three-dimensional conformational radiotherapy.

Irradiating only the breast may account for the lack of dysphagia and nausea in our case [8]. A recently published study in nine patients with bilateral breast cancer has shown that tomotherapy to the breast or chest wall and draining lymph nodes was associated with a high toxicity rate [9]. Furthermore, the patient in this report did not develop radiation skin changes, confirming the observed clinical experience of our center that skin reactions are not an issue with helical tomotherapy. Reducing expansion around the clinical target volume (CTV) to 5 mm supports the findings from other centers [2,3,10].

Conclusions

In this case of bilateral synchronous Stage 1 and Grade 1 breast cancer, helical tomotherapy appeared to be more suitable than direct tomotherapy, providing better planning target volume (PTV) coverage and a lower homogeneity index (HI).

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Conflict of interest

None.

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