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Original article

Comparison between intensity modulated radiotherapy (IMRT) and 3D tangential beams technique used in patients with early-stage breast cancer who received breast-conserving therapy

Beata Sas-Korczyńska[a,*], *Anna Śladowska*[b], *Bożena Rozwadowska-Bogusz*[b], *Sonia Dyczek*[c], *Jan Lesiak*[b], *Anna Kokoszka*[a], *Stanisław Korzeniowski*[a]

[a] *Breast and Thoracic Cancer Unit, Centre of Oncology, Maria Skłodowska-Curie Memorial Institute, Cracow Branch, Garncarska 11, 31-115 Kraków, Poland*

[b] *Medical Physics, Centre of Oncology, Maria Skłodowska-Curie Memorial Institute, Cracow Branch, Garncarska 11, 31-115 Kraków, Poland*

[c] *Diagnostic Radiology, Centre of Oncology, Maria Skłodowska-Curie Memorial Institute, Cracow Branch, Garncarska 11, 31-115 Kraków, Poland*

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ABSTRACT

Background: The most often found complications in patients with breast cancer who received radiotherapy are cardiac and pulmonary function disorders and development of second malignancies.

Aim: To compare the intensity modulated radiotherapy with the 3D tangential beams technique in respect of dose distribution in target volume and critical organs they generate in patients with early-stage breast cancer who received breast-conserving therapy.

Materials and methods: A dosimetric analysis was performed to assess the three radiotherapy techniques used in each of 10 consecutive patients with early-stage breast cancer treated with breast-conserving therapy. Radiotherapy was planned with the use of all the three techniques: 3D tangential beams with electron boost, IMRT with electron boost, and intensity modulated radiotherapy with simultaneous integrated boost.

Results: The use of the IMRT techniques enables more homogenous dose distribution in target volume. The range of mean and median dose to the heart and lung was lower with the IMRT techniques in comparison to the 3D tangential beams technique. The range of mean dose to the heart amounted to 0.3–3.5 Gy for the IMRT techniques and 0.4–4.3 for the tangential beams technique. The median dose to the lung on the irradiated side amounted to 4.9–5 Gy for the IMRT techniques and 5.6 Gy for the 3D tangential beams technique.

Conclusion: The application of the IMRT techniques in radiotherapy patients with early-stage breast cancer allows to obtain more homogenous dose distribution in target volume, while permitting to reduce the dose to critical organs.

* *Corresponding author*. Tel.: +48 12 423 10 52; fax: +48 12 423 10 52.
E-mail address: z5korczy@cyf-kr.edu.pl (B. Sas-Korczyńska).

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1. Background

Radiotherapy is an integral component of breast-conserving therapy in patients with early-stage breast cancer. In these cases, radiotherapy has the effect of reducing locoregional failures in 70% of patients and increasing disease-free survival rates (in 85–90%).[1,2]

This favourable influence on treatment results leads to improved survival. Therefore, the aim of therapy should also be to minimise the risk of complications which may develop in critical organs. In patients with early-stage breast cancer, the critical organs in radiotherapy are: lungs, heart, left anterior descending coronary artery (LAD) and contralateral breast. The most often found complications in these patients are cardiac and pulmonary function disorders and development of second malignancies.[3–6]

Cardiac complications may develop after 10 years following radiotherapy and they are most frequently observed in women with left-sided breast cancer.[2,7–12] These complications cause a 30% increase in cardiovascular deaths after the period of 10 years following radiotherapy.[7]

Other complications related to radiotherapy are those affecting the lungs. Pulmonary complications are confined to antero-lateral peripheral (subpleural) region of the lung on the irradiated side. They are usually divided into early and late complications. Immediately after radiotherapy, patients may develop radiation pneumonitis which later evolves into lung fibrosis.[3]

The lower risk of complications connected with radiotherapy correlates with reduction of dose and irradiated volume in critical organs.[11–13] This effect has been observed for radiotherapy techniques using 3D CT-based dosimetry methods (conformal radiotherapy, intensity modulated radiotherapy (IMRT), moderate deep inspiration breath hold (mDIBH)).[4,14–16] At the same time, improvements in radiotherapy planning afford possibilities for obtaining more homogenous dose distribution in target volume.

Patients with early-stage breast cancer are at increased risk of second primary malignancies.[3,12] The most often diagnosed are lung cancer, ovarian cancer, sarcomas and contralateral breast cancer.[17–20] The development of second malignancies depends not only on radiotherapy but also on other carcinogenous factors.

2. Aim

The purpose of this paper is to compare the intensity modulated radiotherapy (IMRT) with the 3D tangential beams technique in respect of dose distribution in target volume and critical organs they generate in patients with early-stage breast cancer who received breast-conserving therapy.

3. Materials and methods

A dosimetric analysis was performed at the Oncology Centre in Cracow to assess the three radiotherapy techniques used in patients with left-sided early-stage breast cancer treated with breast-conserving therapy:

Table 1 – The range and median volumes of target, contralateral breast and critical organs in 10 consecutive patients with early-stage breast cancer treated with breast-conserving therapy.

Anatomical structures	Volume [cm^3]	
	Range	Median
Irradiated breast (CTV)	290.3–630.8	486.4
Tumour bed (boost target)	13.7–20.2	17.1
Contralateral breast	307.6–709.8	524.6
Heart	573.4–593.5	584.1
LAD	0.9–1.7	1.2
Lung on irradiated side	1131.0–1270.8	1206.4
Contralateral lung	1272.5–1677.2	1423.1

1. 3D tangential beams (covering the breast) with electron boost to the tumour bed;
2. intensity modulated radiotherapy (IMRT) irradiation to breast with electron boost to the tumour bed;
3. intensity modulated radiotherapy with simultaneous integrated boost (IMRT-SIB).

In each of 10 consecutive patients after breast-conserving therapy the postoperative radiotherapy was planned with the use of all three of the above techniques. All plans performed for linear accelerator *Clicac 2300 C/D* (applying of 6MV photon beam and 12 or 16 MeV electron beams) were prepared employing the *Eclipse* treatment planning system with *Helio* module.

Fig. 1 presents the arrangement of radiotherapy beams in the three techniques being compared.

The target volume (CTV) covered the breast with regard to the tumour bed. The margin of 1 cm was added to CTV to create PTV.

The critical organs for this analysis were: the heart, LAD, the lung on the irradiated side and the contralateral breast.

Table 1 presents the range and median volume of target, the contralateral breast and the other critical organs.

In all cases, the total dose was 42.5 Gy given to the whole breast with boost of 10 Gy given to the tumour bed. The fraction dose amounted to 2.5 Gy.

The energy and gantry of electron beams for boost were individually established depending on a patient's anatomy and localisation of the tumour bed in the breast.

The optimal radiotherapy plans were prepared on the basis of CT scans.

The dose values (range of mean and median) and dose distribution in target volume and critical organs were compared for the three radiotherapy techniques.

4. Results

Table 2 presents details of dosage and Fig. 2 shows the dose distribution in target volume for each of the three radiotherapy technique.

The use of the IMRT techniques enables more homogenous dose distribution in target volume. Furthermore, the use of IMRT-SIB leads to shortening of the treatment time.

The information on doses in target volume and in critical organs in each of the three radiotherapy techniques used are