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Original research article

Selection of patients with left breast cancer for deep-inspiration breath-hold radiotherapy technique: Results of a prospective study

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ABSTRACT

Aim: To assess prospectively which patients with left breast cancer have the dosimetric benefit from the use of deep-inspiration breath-hold radiotherapy (DIBH-RT).

Background: Improvement in selection of patients for DIBH-RT would spare time of radiotherapy staff by removing the need for preparation of two comparative treatment plans.

Materials and methods: Thirty-one patients qualified for whole left breast irradiation underwent breath-hold training and their free-breathing (FB) and DIBH planning-CT were included in the analysis of dosimetric outcome. Mean heart dose (MHD), heart V20 Gy (V20Heart), maximum dose to LAD (LADmax), V20 for left lung (V20L.lung) were recorded from FB and DIBH plans and the differences (Δ) of these values were calculated. If relative improvement of at least 20% for any evaluated dosimetric parameter was found for the DIBH-RT, this plan was selected for treatment. Correlations of Δ of dosimetric parameters with patient-related parameters (BMI, age, PTV, cardiac contact distance [CCD], lung volume at FB) were sought.

Results: In 30 of 31 patients, a predefined reduction in evaluated parameters was achieved. CCD, BMI correlated positively with ΔMHD, ΔV20Heart, ΔLADmax; PTV with ΔMHD and ΔV20Heart ($p < 0.05$; AUC > 0.6); Lung volume correlated negatively with ΔLADmax, ΔMHD and ΔV20Heart. No specific thresholds for the lack of predefined improvement of any dosimetric parameters was identified in ROC analysis. 19/30 (63%) patients with dosimetric benefit completed their RT with DIBH.

Conclusions: Despite a strong correlation between patient-related and dosimetric parameters, we cannot use the anatomical characteristics' thresholds to select patients for whom DIBH-RT will not be considered.

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1. Background

Postoperative radiotherapy (RT) following breast conserving surgery (BCS) in patients with early breast cancer reduces a risk of local relapse by about 16%, which is related to the reduction of the risk of death by 5% within 15 years following diagnosis.[1] Epidemiological and clinical data show the increased risk of cardiac death in women who received RT until the 1980s for left-sided breast cancer compared with patients who received RT for right-sided breast cancer.[2] Cardiac perfusion deficits appear as soon as six months following radiotherapy for breast cancer.[3,4] From five to ten years after adjuvant RT, the risk of arteriosclerosis of coronary arteries increases. These patients, more often than their counterparts not treated with radiation, had symptoms of ischemic heart disease including cardiac infarction.[5]

Some data shows that technological advances, such as better imaging and dose calculation and distribution in RT of breast cancer, which led to the decrease of dose given to healthy tissues with proper encompassing of the target volume, may reduce treatment-related cardiac morbidity. This is of crucial importance in the light of improvement of survival in breast cancer patients. Deep inspiration breath-hold RT (DIBH-RT) has been demonstrated to reduce heart doses. DIBH-RT decreases low and high doses given to the heart, left anterior descending artery (LAD), and sometimes doses to the left lung with preservation of the dose coverage and distribution within the planning target volume (PTV).[6–13] However, data about factors that may impact the dosimetric benefit from DIBH-RT are scarce.[6,12–15] The routine use of this technique increases the treatment cost because of the significant increase in the staff workload and the necessity of acquiring and servicing new equipment. This is also a demanding technique for patients, which requires some degree of cooperation, effort and engagement for the procedure to be performed properly. Special measures to ensure the reproducibility and stability of DIBH-RT, such as monitoring of treatment by a real-time 3-dimensional (3D) surface imaging system, increase the time of treatment delivery and represent an additional burden not only for RT staff but also for patients. All of these factors are of special importance in the busy RT department, where each increase of the workload dedicated to one group of patients may reduce the number of treated patients and lengthen their waiting time.

2. Aim

Therefore, we decided to carry out a prospective study to evaluate the extent of dosimetric benefit from the use of DIBH-RT technique in patients with left breast cancer in relation to the patient-related factors. We tried to identify the anatomical characteristics thresholds to select patients for whom DIBH-RT will not be used. We expected that the results of this study would enable improvements in the selection of patients for routine use of DIBH-RT in the future without having to prepare two comparative treatment plans for free breathing (FB) and DIBH-RT.

3. Patients and methods

3.1. *Patients selection*

We intended to include in the study 30 consecutive patients with early stage left breast cancer referred for adjuvant RT following BCS who agreed to be treated with this technique and participate in the study. Inclusion criteria were: age between 18 and 70 years, invasive ductal carcinoma staged pT1–T2, N0–N1a, M0 or ductal carcinoma in situ and signature confirming informed consent to participation in the study. Excluded patients were those who did not agree to participate, who were unable to cooperate in the DIBH training or who had respiratory function impairment that precluded them from deep inspiration maintenance.

3.2. *Treatment planning*

Included patients were given instructions and were trained by dedicated RT staff to calmly breathe and hold their deep inspiration for about 20 s. The patients then underwent a FB and DIBH computed tomography (CT) scan. Two separate treatment plans were prepared: one for FB and one for DIBH. Contouring of clinical target volume (CTV) was performed according to published guidelines.[16,17] PTV was generated by expanding CTV by 6 mm in all directions, but not closer than 5 mm to the skin in both CTs. Critical structures (heart, LAD, lung, skin) were contoured without margins. Delineation of the heart and LAD was performed according to published guidelines.[18] All delineations in this study were done by one person (BC).

The prescribed dose was 39.9 Gy in 15 fractions during 3 weeks. Patients were treated with tangential conformal fields with a multileaf collimator using 6 MV photons. The field-in-field technique was used to avoid hotspots. There were no special requirements for fields geometry and shape. Boost for the lumpectomy cavity was also prescribed if indicated; however, this part of treatment was realized at FB and was not subject of this study. Two plans were compared with regard to the covering of PTV by 93% isodose, maximum dose for LAD (LADmax), volume of heart receiving 20 Gy (V20Heart), mean heart dose (MHD), and volume of left lung receiving 20 Gy (V20L.lung). Patients were treated with DIBH if there was an improvement of at least one evaluated dose metric in the DIBH treatment plan compared with the FB treatment plan. Improvement in the DIBH treatment plan was defined arbitrarily as a relative reduction by at least 20% of any studied dose metrics compared with the FB plan without clinically significant worsening of other parameters as judged by treating physician and maintained covering of PTV with a 93% isodose. Patients that had no sufficient improvement of treatment plan or were not able to hold deep inspiration steadily were treated according to the FB plan. Additionally, relative improvement by 50% of evaluated dose metrics was assessed.

3.3. *DIBH-RT technique*

Treatment was realized using 6 MV photons on the linear accelerator equipped with a real-time 3D surface imaging