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Set-up uncertainty during postmastectomy radiotherapy with Segmented Photon Beams Technique

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ABSTRACT

Aim: To verify the reproducibility of patients irradiated after mastectomy on the immobilization system designed and manufactured for our hospital and to compare the Internal Protocol (IP) with the modified-No Action Level Protocol.

Background: Application of forward IMRT techniques requires a good reproducibility of patient positioning. To minimize the set-up error, an effective immobilization system is important.

Materials and methods: The study was performed for two groups of 65 each. In the first group, portal images for anterior field were taken in 1–3 fractions and, subsequently, three times a week. In this group, the mNAL protocol was used. In the second group, the IP was used. The portal images from the anterior field and from the gantry 0 were taken during the 1–3 and 10 fractions. In both groups, image registration was performed off-line. For each group the systematic and random errors and PTV margin were calculated.

Results: In the first group the value of the population systematic errors and random errors were 1.6 ± 1.6 mm for the left–right, and 1.5 ± 1.7 mm for the cranial–caudal directions, respectively, 1.7 ± 1.3 mm, and 1.9 ± 1.3 mm for the second group. The PTV margins for the left–right and cranial–caudal directions were 5.1 and 4.9 mm for the first group and 5.4 and 6.4 mm for the second group.

Conclusions: For patients immobilized with our support device treated according to the mNAL protocol or IP, a good set-up reproducibility was obtained. Implementation of IP limits the number of required images.

1. Background

Breast cancer is the most common malignant tumor among women. Different types of treatment are used for breast cancer patients. For some patients radiation therapy is applied after mastectomy. Some of them start with mastectomy followed by post-mastectomy radiotherapy.[13] Post-mastectomy radiation is technically difficult due to complexity of the target volume and its close proximity to critical structures, including the heart, lung, brachial plexus and contralateral breast. Many different techniques have been proposed for post-mastectomy

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irradiation. Pierce[12] described several commonly used treatment techniques: standard tangents, electron fields, reverse photon electron technique, photon electron mix technique. None of these is considered as the gold standard. Nowadays, more and more often, the state-of-the-art IMRT techniques are used.[2,4,5]

In order to ensure delivering the prescribed dose to the CTV throughout the entire course of irradiation, margins must be added. The ICRU[9] recommends adding margins adequate to the chest wall, supraclavicular and axillary nodes in order to account for variations in the position, size and shape of the target (internal margin) and for uncertainties in patient positioning (set-up margin). To minimize the set-up errors, the effective immobilization systems, suitable for a given location, should be used. There are several commercially available immobilization systems designed for positioning of patients irradiated in the thorax region.

2. Aim

In this study, we evaluated the immobilization system designed in our hospital. We also compared two protocols of set-up correction: the modified-No Action Level (mNAL)[7] and the Internal Protocol.

3. Materials and methods

3.1. *Patients*

Patients with T2–T3 breast cancer were included in the prospective study for evaluation of the immobilization system which was designed and manufactured for our hospital. We did not make any selection based on the tumor stage or body habitus. The study was performed for two groups of consecutive patients treated in our hospital. There were 65 patients in each group. In the first group (the mNAL group), the portal images were taken 12–17 times during the treatment. For the second group (the Internal Protocol group), the portal images were taken during the first three fractions and in the middle of the treatment.

3.2. *Treatment techniques and patients' set-up*

For all patients, a treatment planning CT was made in the treatment position. The planning CT scans were acquired from the thyroid cartilage to 2 cm below the lower border of the healthy breast with 5-mm slice thickness in the spiral mode. Patients were treated with forward-IMRT Segmented Photon Beams Technique.[14] Their radiotherapy plan consisted of 6 isocentric photon beams of 4 MV and 15 MV X-rays. There was one isocenter for all beams. Isocenter point was located near the top of the lung on the irradiated site.

Plans were prepared according to the International Commission on radiation Units and Measurements guidelines with the Precise Plan treatment planning system (version 2.15). Patients were irradiated on the Elekta Synergy accelerator equipped with the MLC and electronic portal imaging device (EPID). The total dose of 45 Gy in 20 fractions was administered. More details about the irradiation technique can be found elsewhere.[14] After placing a patient on the immobilization system, the therapeutic position was achieved by aligning three skin tattoos with the laser system. Tattoos were made on the medial surface, on the left and right side of the thorax at the level of the sternum. An additional tattoo was always marked on the medial line in the infraclavicular area.

Fig. 1 – The support device of our construction.

3.3. *Immobilization system*

Fig. 1 shows the immobilization system. Patients were placed supine with arms placed on acrylic supports with hands holding individually positioned hands grips and with their head placed on the commercially available head support (Orfit Industries). Our support device enables to carry out the planning computed tomography in the therapeutic position, even if the CT aperture is quite small. The support device is easy to handle, its weight being 2 kg only. Patients, who due to other coexisting diseases could not be positioned on the support device, were placed either on a Sinmed board or on a vac-lok mattress. These patients were excluded from this study.

3.4. *Set-up errors*

Set-up errors were defined as a geometric difference between digitally reconstructed images and treatment fields position with respect to bony landmarks. For each patient, two DRRs were reconstructed. The first one was for the open field at gantry 0° with size covering all the irradiated regions. The other one was one of the main segments of the oblique fields at gantry angle of about 50°.

In Fig. 2, examples of these DRRs are shown. Bony structures used for image registration are marked in green. The set-up errors were measured for the left–right (l–r) and cranial–caudal (c–c) directions. For both groups of patients, the image for the oblique field was used to check if the anterior–posterior (a–p) direction was set correctly. The errors made in the a–p direction set lead to errors in dose delivery.