18 Simulation for Breast Cancer

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18.1 Background

18.1.1 Simulation for Breast Cancer

For breast cancer irradiation preparation, a simulation process has to be performed. During this process the patient position will be determined. Furthermore, treatment simulation allows to locate the irradiation area (i.e. target volumes) and the critical organs (Organs At Risk, OARs) that need to be avoided or taken into consideration at the time of radiation treatment planning. A planning CT scan is commonly used for breast cancer irradiation simulation. For the RT workflow this is called CT simulation (i.e. this scan is not used for diagnostic purposes). The aim of the latter is to scan the patient in a reproducible position that will serve as treatment position, lying on RT-specific immobilisation devices (see Chap. 17). Different targets and indications require different positioning of the patient, to allow for a reproducible position and safe treatment. This chapter will focus on simulation for breast cancer, after BCS or mastectomy, with/without regional nodal irradiation.

18.2 Simulation Process

Usually, the patient is lying in the supine position on an inclined immobilisation device, preferably indexed to the treatment couch, with one or two arms raised [1, 2]. Depending on the target volumes that need to be irradiated, only local breast irradiation or more extensive irradiation including regional nodal areas, the head of the patient may be placed in a central position or turned to the contralateral side of the affected breast (see Chap. 17) [1, 2]. Nowadays, anatomically defined target volume definition guidelines have been introduced widely. This resulted in treatment volumes with more caudally located cranial borders, allowing a central position of the head irrespective of the target volumes to be included. The latter needs to be decided in the department according to the local medical protocols, taking into account that standardisation favours avoidance of errors. For patients with large pendulous breasts a prone or lateral decubitus position is a possibility [3].

There are different types of CT scanners from several manufacturers. Depending on the type of the CT simulator, the RTT needs to take precautions to avoid collision with the arms or the used immobilisation device. A specific option for RT

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O. Kaidar-Person et al. (eds.), *Breast Cancer Radiation Therapy*,
https://doi.org/10.1007/978-3-030-91170-6_18

Fig. 18.1 Wide-bore RT CT scanner. Example of an inclined breast board immobilisation device (IT-V, Innsbruck). The use of the pelvic rest/stopper or knee/feet rest avoids the patient to slide down the immobilisation device

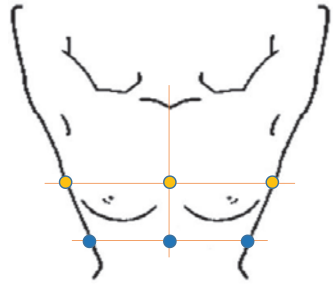

Fig. 18.2 An example of the position of the marks, this needs to be decided in the department. The reference point (0,0,0) is marked in blue. This might be a stable anatomical point to set the reference. The orange points could be helpful to outline the patient on the Linac

departments is a CT simulator with a large bore, providing the RTT more degrees of freedom in placing the patient on the RT immobilisation device on the CT simulation table and avoiding collisions with the patient (Fig. 18.1). To avoid the patient sliding down the inclined treatment couch, if the patient is positioned in supine position, additional devices can be added on the table to assist the patient to stay in the same position on the treatment table [4].

When the position of the patient is identified, the treatment planning reference point (or 0,0,0 point) is marked on the patient with a washable marker pen: one point at patient sagittal mid-line, two points at each side of the patient, all three halfway the chest since these are stable points. Cranial and/or caudal points can be added to improve patient alignment at sagittal level (Fig. 18.2). After that, artefact-free opaque markers are placed on this reference point, therefore the reference point will be visible during the treatment planning process.

The reference point is determined by using external fixed or mobile laser beams which are positioned in the CT simulator room, typically within a certain distance (i.e. 50 cm) to the CT isocentre, to allow for more working clearance. An accuracy of less than 2 mm between the imaging plane and the laser marking plane is a prerequisite for positioning the patient [5]. The reference point will be used on the linear accelerator to set-up the patient according to the position that was determined during the CT simulation, and will allow for manual/automatic movement to the planning isocentre. According to the protocols in the department several points can be placed. These points can be helpful to set-up the patient in the same position on the linear accelerator (Fig. 18.2).

Placing a radiopaque wire to mark the breast volume may be helpful at time of delineation. The wire, if done mindfully, may assist in identifying the borders of the CTV breast/chest wall. For example, the subcutaneous fold around the chest/breast from the breast itself, which is sometimes easier to identify on the patient (by appearance and palpation), especially in patients with small breasts and no infra-mammary fold. Thus, placing the wire correctly at the border of the glandular tissue as noted by palpation can be of assistance in identifying the inferior part of the breast in patients where the infra-mammary fold is not easily identified on CT simulation. The lumpectomy or mastectomy scar or other specific landmarks can be marked with a radiopaque wire as well, this is determined after consulting the radiation oncologist.

When all preparations are completed, using the external laser system to define the reference plane, the patient is moved into the CT simulator gantry. The distance from external lasers to the CT acquisition isocentre is fixed and set at the initial equipment/laser system installation.

During the acquisition phase, one or two scout views are made, depending on local standard operational procedures. On the scout views the RTT defines the field of view (FOV), to cover the entire body contour. The acquisition length would be enough to include all target volumes and OARs, plus a 5 cm margin to take into account the irradiation beams divergence and penumbra. Careful definition of the FOV and acquisition length must be performed, coupled with optimal pitch and slice thickness. For optimal reconstruction, the use of a helical CT scan is recommended with a pitch around 1:1, and a slice thickness of less than 5 mm, but preferably 3 mm. For breast cancer RT simulation, CT acquisition with intravenous contrast would not be necessary for defining the target volumes or OARs. Finally, the reference point and other points can be replaced by semi-permanent or permanent markers. Those markers need to be placed to guide the RTTs in positioning the patient on the linear accelerator. When a patient is lying in prone position, markers need to be placed on the patient's back and sides and another can be placed on the lateral aspect of the breast [3, 6]. More advanced technologies such as Surface Guided Radiation Therapy (SGRT) or adaptive linear accelerators provide meaningful changes on workflows in RT, with improvement of positioning and isocentre localisation, allowing for marker-less planning and treatment delivery. These techniques are described more extensively in the treatment delivery section.

The RTT is responsible for reporting the used immobilisation devices and if applicable other patient-specific positioning details. Colour photographs of the position of the patient can be of added value. The CT data is forwarded to the treatment planning system after the reconstruction of the images was completed. All this information is necessary for the next step in the RT workflow.

18.3 Positioning a Bolus at Time of Simulation

In some cases, a bolus is needed for PMRT or less often after BCS. We recommend that in such cases the bolus will be placed at time of CT simulation. By placing it at time of simulation it will provide information of how the bolus shapes to the body at the time of treatment planning, adjust for air gaps to reduce them as possible. A simulated bolus added in the treatment planning system will not reflect the true shape and size of the real bolus. Additionally, at time of CT simulation the team can adjust the bolus and cut/shape the bolus to areas that are at high risk and reduce the air gaps.

18.4 Deep Inspiration Breath-Hold (DIBH) Technique

When using a Deep Inspiration Breath-Hold (DIBH) technique in patients with left-sided breast cancer, or in some cases of right-sided irradiation, to reduce the dose to the heart and coronary arteries, lung, and liver (depending on patient's anatomy) a slightly adapted workflow needs to be used. As indicated in the positioning section, it is important to make sure the patient is feeling relaxed in her/his surroundings. If the patient is relaxed, it increases the chances to be more compliant with DIBH at time of simulation and treatment. Therefore, it would be recommended that RTTs first start with a clear explanation of the overall procedure that might include:

1. Demonstration of measuring/monitoring devices (optical surface detection (SGRT), spirometry)
2. Audio (e.g. intercom, earphones) and visual feedback (e.g. goggles, mirror, and screen)
3. Ensure a stable breathing cycle throughout the procedure
4. Breathing technique, with focus on upper chest (attention must be paid to avoid, arms and neck contraction, as well as back uplift)
5. Duration of deep inspiration breath-hold, preferably above minimum required time for full-length CT scan helical acquisition, typically between 15 and 30 s (optimal acquisition for reduction of temporal artefacts)

If the protocols in the department prescribe a free breathing and a DIBH scan, the same reference point is used. Furthermore, the position of the radiopaque wire needs to be checked in between these two CT scans.

18.5 Summary

For breast cancer irradiation, CT simulation is one of the important stages for treatment planning and delivery. The CT scan is used for delineation of the target volumes and the OAR, as well as for treatment planning dose calculation. After defining the position of the patient, the treatment planning reference point (0,0,0), and other essential markers, the CT scan will be performed. The reference points are used to position the patient on the Linac. The CT procedure can be performed in free breathing and breath-hold, both scans making use of the same reference point.

Advanced technologies such as optical surface devices and adaptive technologies would provide meaningful changes on workflows in RT, with improvement of positioning and isocentre localisation, allowing for marker-less planning and treatment delivery.

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