Challenges of maintaining breath-hold conformity for breast patients while using the deep inspiration breath-hold technique

Marianne Dabbs  
Radiotherapy practice development manager

Matt Bolt  
Radiotherapy physicist

Sandra Dymond  
Radiotherapy planner

Royal Surrey County Hospital, Guildford, Surrey
email: marianne.dabbs@nhs.net

Introduction

Deep inspiration breath-hold (DIBH) is used for whole breast radiotherapy, as a means of providing better dose homogeneity. This can be achieved by lower doses to the organs at risk, less patient movement and better set up. Most patients offered DIBH treatment are left-sided breast cancer, or ductal carcinoma in situ (DCIS) patients, due to the proximity of the heart to the chest wall so it is nearer the radiation field. However, if lung sparing is essential for the patient, DIBH offers a solution for right-sided breast cancer patients also.

St Luke’s Cancer Centre at Royal Surrey County Hospital introduced a DIBH service in June 2012 for left-sided breast cancer patients. This service was initially introduced at a low level, with the increase in capacity over the course of 18 months achieving a service roll out to all left-sided breast patients, and selected right-sided breast patients.

The Varian Real-time Position Management (RPM) system is used in the GE computed tomography (CT) scanner, and on the Varian Linacs. The marker box is placed horizontally onto the patient’s chest. This permits the in-room camera to detect the reflective markers.

An assessment of the patient’s ability to hold their breath must be taken at the CT scanning appointment. Several practice sessions are performed before the DIBH CT scan is acquired to ensure that the patient can maintain a reproducible and constant deep inspiration breath-hold for the duration of the scan and for treatment, and is comfortable with the requirements.

The patient must be able to take regular breath-holds, each being for a minimum of 15 seconds. It is also worth noting that the threshold (amplitude of the breathing trace) of the breath-hold should be assessed at this point to ensure the breath is deep enough to ensure reproducibility at treatment.

Once the patient is comfortable with this procedure the DIBH scan is performed during a single breath-hold. To align the patient for treatment they are required to be in breath-hold. Once treatment commences, the linac will only deliver radiation when the marker box is detected in the breath threshold window as defined during the CT appointment using the RPM system.

Reproducibility of breath-hold

A visual coaching system was employed from the start of the project, using standard video goggles. Visual coaching has been shown to provide good reproducibility and stability of the amplitude of breath. Patients use the on-screen slide bar view to gauge the level of their breath threshold.

The video goggles, which may be worn with a patient’s own prescription glasses, provide a clear and crisp screen for the patients during the scan and treatment. Use of the video goggles does, however, come with some issues. Unless using a wireless system the cabling of the goggles can be cumbersome. The goggles are commercially available for gaming, and were therefore not designed for a clinical setting, so they were not found to be robust in clinical use.

During treatment the live breathing trace can only be shown to the patients when no adjustments to the patient or couch position are made. Once an adjustment is made the recording of the breathing trace needs to be reset. This can be time consuming. We have overcome this by using audio coaching until the patient is in the correct position, then switching to visual, ready for the commencement of treatment.

Some patients will produce different amplitude levels between the audio and visual prompt, which was shown in the study by Rohini et al. In this situation, the visual prompt will be introduced earlier to align the patient, but will be reset frequently during set-up as the correct position is obtained.

Communication from the radiographers to the patient via an intercom system assists the patient with their breathing prior to, and during, the treatment delivery. The patients are actively encouraged to control their own treatment with their breath-holds.

Maintaining compliance

It is important that the patient has a good understanding of the DIBH technique. It became apparent from the outset that clear and concise explanation of the technique was required to ensure the patient had full comprehension of the task asked of them.

All patients are now sent a specific patient information leaflet and a letter with their initial appointment details. This information explains the procedure and requests that patients practice taking breaths prior to their first appointment. By using a visual aid to demonstrate to the patients prior to their scan they get a good understanding of what they will see on the screen, and what they are aiming to achieve.

Some patients have been unable to reach the reference threshold. There have been various contributing factors for this:

- The patient has not been in sufficiently deep breath-hold at the baseline recording with the amplitude only slightly above the normal inspiration breath-hold. This then becomes unachievable for the patient once on treatment, as they tend to go over the threshold. Figure 3 shows the comparison of a successful breath-hold at treatment, compared to a breath-hold that exceeded the upper threshold level.
- Some patients appeared to be in overly deep breath-hold at CT, and were subsequently unable to reach the same breath-hold threshold again. This could happen if the patient has not taken regular breaths at the scan to practice, therefore producing an unsustainable breath-hold level. Pre-scan coaching was further introduced, resolving this problem.

There have been a small number of patients that have a baseline recording that is visibly recorded at different levels. These resulted in the patients being unable to reproduce the breath-hold in the treatment room. This led to a new baseline being recorded at the treatment RPM. After some
investigation, presented by Bolt and Jones in 2013, it became apparent this was due to the camera being adjusted after the tracking had been started at the CT scanner. Staff awareness, additional training and introducing an extra check at the scanner stage rectified this problem.

The position of the marker box is important to ensure reproducibility of the breath-hold. To capture a true reflection of inspiration level for breast patients the box needs to be on the sternum. If placed too low, it will be distorted by the movement of the abdomen. Staff training in these issues is paramount. Full awareness of the use of the RPM and the issues surrounding the breath-hold technique need to be understood by all staff involved.

**Data collection**

A planning assessment was conducted which looked at six of the early patients receiving DIBH, who were scanned in breath-hold and free breathing (to provide a backup in the event that breath-hold was not sustainable on treatment). The treatment fields from the DIBH scan were transferred to the free breathing scan, based on the border positions. The heart, lung and left anterior descending artery (LAD) doses were evaluated. For the heart and LAD, there was a decrease in the maximum dose with DIBH, but in only one of the patients was a significant reduction in mean doses for these organs seen. Similarly, only this one patient showed a reduction in the volume of heart receiving 25Gy. This patient had a medial, central tumour. In terms of lung doses, the only significant difference was seen for this same patient who showed an increase in lung dose.

The reason for these small differences may be that the breast planning technique at our centre has historically had a shallow posterior border to ensure heart and lung sparing, and this should be re-evaluated for patients in DIBH. A further planning study will look at this. However, for the patient where the heart significantly encroached into the tangential fields due to its location, DIBH showed a clear improvement in heart dosimetry. It is also worth noting that all DIBH patients will benefit from the improved inhomogeneity that results from preventing motion during treatment delivery.

**Conclusion**

DIBH is a practical, achievable technique that patients comply with well. Visual coaching is easy and clear for the patient and provides increased reproducibility of the breath-hold threshold. DIBH can, however, be successfully achieved using audio coaching.

Care needs to be taken when deciding the method of visual coaching to ensure that it is compatible with the departments set up. Patient compliance can be achieved, providing the patients receive adequate information on the technique, and are given the opportunity to practice prior to the baseline recording.

The baseline recording is crucial in the reproducibility of the breath-hold at treatment; a ‘deep breath’ cannot be quantified, which leads to difficulty when determining sufficient amplitude, this therefore needs to be determined on an individual basis. By having well trained staff these issues can be minimised to achieve a successful and efficient service.

**Acknowledgements**

Thanks to all the staff that have assisted with the set-up and smooth running of the service.

**References**


<table>
<thead>
<tr>
<th>Max doses for heart and LAD</th>
<th>A decrease in doses shown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean doses for heart, LAD and heart V25 Gy</td>
<td>5/6 patients no significant change in the 1/6 patients showed there was a significant difference – this was a medial, central tumour</td>
</tr>
<tr>
<td>Lung dose</td>
<td>Little change in 5/6 patients 1/6 dose increased</td>
</tr>
</tbody>
</table>

**TABLE 1** Planning data.
Figure 1
The slide bar picture of the Varian RPM system that patients view on the goggles.

Figure 2
Patient set-up wearing the goggles with the Varian RPM system.

Figure 3a
Successful breath-hold treatment.

Figure 3b
Breath-hold that exceeded the upper threshold level.