Application of surface image guided radiotherapy (SIGRT) for deep inspiration breath-hold and free breathing gating technique in Pantai Hospital Kuala Lumpur

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Abstract. Pantai Hospital Kuala Lumpur (PHKL) has integrated Surface Image Guided Radiotherapy (SIGRT), C-RAD Catalyst HD camera in radiotherapy treatment over the 12 months. It eases us in setting up patients before treatment, monitoring intrafraction treatment and allows Deep Inspiration Breath-Hold (DIBH) treatment delivery. Positioning patients using Catalyst gives correctable error in 6-dimension and the shifts were small and acceptable. However, C-RAD is not the gold standard for positioning compared to CBCT but it has the advantage in terms of monitoring patient surface motion during treatment especially DIBH treatments. Target volume coverage for DIBH plan is improved by 0.6% to 1.8% compared to FB plan. This study also compare dose to the heart using DIBH technique over the free breathing (FB) technique for left breast cases. Maximum dose to the heart in DIBH is reduced by 18% compared to FB. Treatment of left breast with DIBH results in significant reductions in doses to the heart, since the distance between the target and the heart is increase compare to FB technique.

1. Introduction
In the past decades, SIGRT has been gradually recognized on its rationality in radiotherapy treatment. The 3D camera and infrared projector technologies applied in the system is able to track patient’s skin and detect any large motion from the patient on-line. The CRAD system enables the users to do immediate posture correction, ensuring precise patients positioning using non-ionizing radiation without additional radiation dose.

One of the common and effective treatment for breast cancer is radiotherapy. Radiotherapy is used to deliver the prescribed radiation dose to the entire breast and the regional nodes, while minimizing the dose to the surrounding healthy tissues. However, in left sided breast case, this is quite difficult to achieve as the heart tend to be irradiated as well due to its proximity to the anterior chest wall. The primary aim of DIBH is to reduce radiation dose to the heart while maximizing the dose to the breast.

2. Materials and Methods

2.1. DIBH vs Free Breathing for Left Breast Cancer
DIBH technique was used to increase the distance of the heart from the chest wall without compromising the dose to target volume.
2.1.1. Image Acquisition. The planning CT images were acquired using Aquilion LB CT Scanner. CT images were acquired for normal FB cycle and DIBH.

2.1.2. Treatment Planning. The planning CT images were transferred to MonacoSim for contouring purpose. The organs at risk (OARs) were contoured by physicist while target volume was contoured by oncologist at both image sets. VMAT treatment plans were generated for both FB and DIBH image sets using Monaco 5.11. In this study, the distance between the heart and chest wall was analysed at the center of the heart in free breathing and on the corresponding plane in DIBH.

2.2. Application of SIGRT

SIGRT is used for patient positioning, intra-fraction motion management and DIBH gating.

2.2.1 Image Acquisition. Patient was given a goggle to help them to monitor their breathing pattern during simulation and treatment procedure. During simulation, the level of inhalation by the patient was worked out together with RTT at patient comfortable level.

2.2.2. Treatment Delivery. For the first fraction, the settings of the Catalyst camera were adjusted base on individual patient. Isocenter shift was done using Mosaiq system and verified by using CBCT. After image registration, patient position was captured on Catalyst in Cposition mode and isocenter was marked on patient body. During treatment, patient motion was monitored by the catalyst camera in Cmotion mode. For the next fractions, the captured position in Catalyst Cposition mode at the first fraction were used for patient positioning along with lasers and isocenter body markings. The 6-Dimensional positioning errors were corrected by repositioning the patient. CBCT was done daily to ensure target accuracy.

2.2.3. Body Surface Gating. Patient body surface was monitored throughout the treatment. Treatment delivery was paused by C-RAD system if there is unstable breathing pattern or movement such as coughing, sneezing. The treatment delivery was resumed once the body surface is below 5 mm tolerance.

3. Results and Discussion

3.1. Dosimetric Analysis

DIBH technique is used to increase the volume of the lung and move the heart away from the chest wall without compromising the dose to the target volume.

![Figure 1. Location of the heart in FB (a) and DIBH (b)](image-url)
Figure 1 shows the location of the heart from the chest wall on the reference plane in FB and on the corresponding plane in DIBH for left sided breast case. The distance of the heart from chest wall for FB is 1.58 cm while for DIBH is 3.2 cm.

![Figure 1: Location of heart from chest wall in FB and DIBH (a) and (b)](image)

**Figure 2.** Isodose distribution in FB (a) and DIBH (b)

According to Figure 2, the target volume coverage showed insignificant differences between the DIBH and FB plans. With DIBH, there was no compromise in doses to the target volume with respect to coverage. In our study, the target volume coverage in DIBH plan was 0.6% to 1.8% improved compared to the FB plan.

**Table 1.** Criteria for target volume and heart tolerance dose

| Target | Criteria | Free Breathing | DIBH       |
|--------|----------|----------------|------------|
| PTV1   | $V_{100%Rx}$ | 98.13%         | 98.76%     |
| PTV2   | $V_{95%Rx}$  | 97.24%         | 99.00%     |
| OAR    | Criteria  | Free Breathing | DIBH       |
| Heart  | Max dose  | 3760.90 cGy   | 3079.00 cGy|
|        | Mean dose | 1385.10 cGy   | 1233.30 cGy|

Based on Table 1, there was a significant reduction in dose to the heart in the DIBH plans compared to the FB plans. There was a 18% of reduction in maximum dose to the heart compared to the FB plan.

3.2. Treatment Delivery

CBCT is carried out daily on each treatment fraction in PHKL. After image registration, the translational shifts from CBCT were obtained to verify with the SIGRT shift. Based on Figure 3, it is shown that majority of the shifts are within the tolerance.
Figure 3. Graphs of percentage of shift deviation versus number of fractions in 3 Dimension

There are several fractions with shifts more than 1% in one of the 3 translational direction. This may due to the patient physical changes daily. For example, flabby skin. Due to this, we still carry out CBCT for verification.

4. Conclusions
C-RAD helps in patient positioning and patient motion during intra-fraction treatment. Besides, the DIBH technique allows concentrated high dose to tumor while minimizing the radiation dose to the surrounding heath tissue. The maximum dose to the heart can be reduced significantly with the use of DIBH technique as the distance between the target and heart is increased. At the same time, patient can feel relax during treatment. Nevertheless, CBCT is still the gold standard for position verification as it can verify real-time positioning based on patient’s anatomy.

5. References
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