The benefits evaluation of abdominal deep inspiration breath hold based on knowledge-based radiotherapy treatment planning for left-sided breast cancer

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SUBJECT AREAS
Oncology

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Deep inspiration breath hold, dose distribution prediction, knowledge-based planning, machine learning, breast cancer
Abstract
Purpose Study the impact of abdominal deep inspiration breath hold (DIBH) technique on knowledge-based radiotherapy treatment planning for left-sided breast cancer to guide the application of DIBH radiotherapy technology.

Methods and Materials Two kernel density estimation (KDE) models were developed based on 40 left-sided breast cancer patients with two CT acquisitions of free breathing (FB-CT) and DIBH (DIBH-CT). Each KDE model was used to predict DVHs based on DIBH-CT and FB-CT for another 10 new patients similar to our training datasets. The predicted DVHs were taken as a substitute to dose constraints and objective functions in the Eclipse treatment planning system, with the same requirements for the planning target volume (PTV). The mean doses to the heart, the left anterior descending coronary artery (LADCA) and the ipsilateral lung were evaluated and compared using the T-test among clinical plans, KDE predictions, and KDE plans.

Results Our study demonstrated that the KDE model can generate deliverable simulations equivalent to clinically applicable plans. The T-test was applied to test the consistency hypothesis on another 10 left-sided breast cancer patients. In cases of the same breathing status, there was no statistically significant difference between the predicted and the clinical plans for all clinically relevant dose volume histogram (DVH) indices (p>0.05), and all predicted DVHs can be transferred into deliverable plans. For DIBH-CT images, significant differences were observed in Dmean between FB model predictions and the clinical plans (p<0.05). DIBH model prediction cannot be optimized to a deliverable plan based on FB-CT, with a counsel of perfection.

Conclusion This study demonstrated that the KDE prediction results were well fitted for the same breathing condition but degrade with different breathing conditions. The benefits of DIBH can be evaluated quickly and effectively by the specific knowledge-based treatment planning for left-sided breast cancer radiotherapy. This study will help to further realize the goal of automatic treatment planning.

Full Text
Due to technical limitations, full-text HTML conversion of this manuscript could not be completed.
However, the manuscript can be downloaded and accessed as a PDF.

**Figures**

| THE WORKFLOW OF THIS STUDY | PERFORMANCE EVALUATION |
|----------------------------|-------------------------|
| Two CT scans (FB and DIBH) | FB model                |
| Model training (FB and DIBH) | Clinical plan VS. KDE prediction |
| Model cross prediction | DIBH model              |
| Performance evaluation | Clinical plan VS. KDE prediction |

**Figure 1**

The strategy of knowledge-based planning generated optimization objectives
Figure 2

The DVHs of the prediction (solid line) and the deliverable plan (dashed line) for (a) FB model work with FB-CT; (b) DIBH model work with FB-CT; (c) FB model work with DIBH-CT; (d) DIBH model work with DIBH-CT.