4D CT With Respiratory Gating Helps Locate and Track Lesions to Reduce Target Volumes

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In order to improve accuracy in radiation therapy for chest and abdomen cancers, it is necessary to visualize, control, and track patient specific respiratory motion. Tumors near or around the diaphragm will likely move with respiration.

Without the means to limit respiration-induced target or organ motion, large treatment fields have to be used, potentially resulting in more irradiation of surrounding normal tissues. As a result, the risk of complications may increase. Conversely, if smaller treatment fields are used, the target may move out of the treatment field resulting in an under dose to the target. Some techniques such as breath-holding, forced shallow breathing, and respiratory-gated treatment techniques have been implemented to account for respiratory motion.

Therefore, precise targeting of the tumor and tracking of respiratory motion are important to patient outcomes.

Since October 2009, we have used Varian's Real-time Position Management™ (RPM) System, which uses an infrared tracking camera and reflective marker to measure the patient's

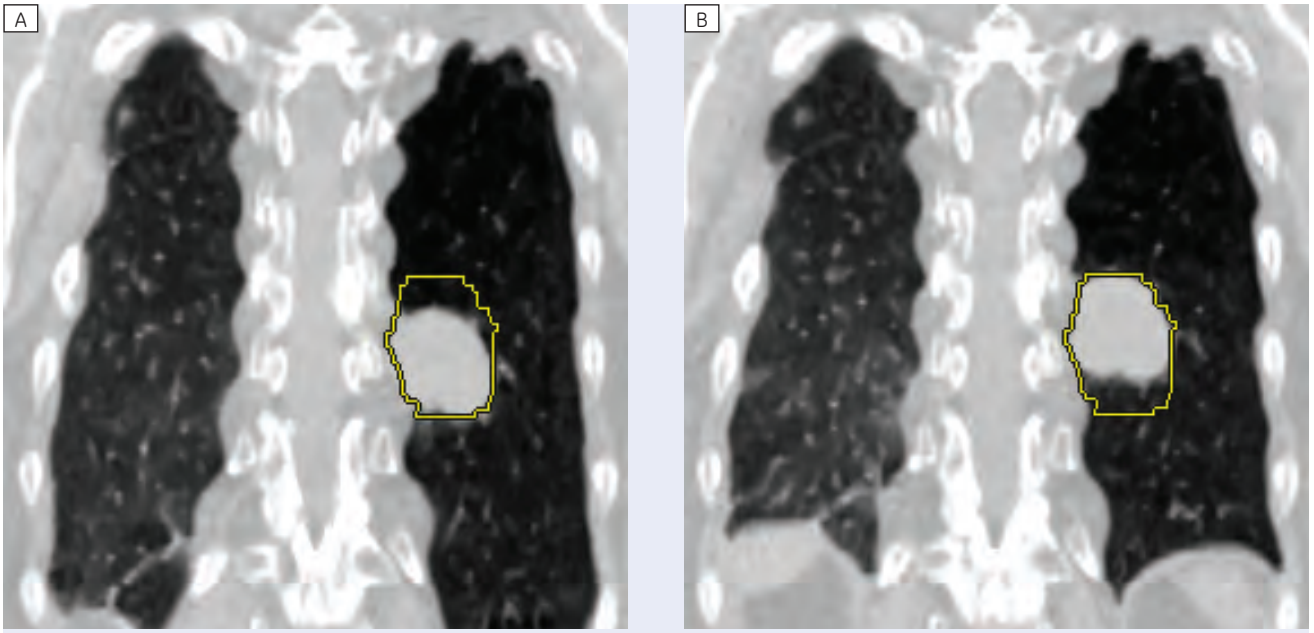

Figure 1. (A) Illustrates lesion location in inspiration; **(B)** shows lesion location in expiration, demonstrating the movement of the lesion during the respiratory cycle.

Real-time Position Management (RPM) System is a trademark of Varian Medical Systems, Inc.

We are able to deliver effective patient treatment with customized treatment plans based on each patient's respiratory cycle.

Dr. Xiaodong He

respiratory pattern and extent of motion. Advantage 4D*, a respiratory motion management application on the Advantage Workstation, helps providers analyze respiration-induced motion of anatomy based on data acquired using the Varian RPM in conjunction with the GE RT CT system.

Prior to treatment planning, patient CT images are acquired and processed in 4D. The patient is scanned using a Cine CT respiratory protocol and the respiratory waveform file is simultaneously recorded with an external respiratory gating system, e.g., RPM. The Advantage 4D software then sorts and saves the Cine CT image data into phases and intensity projections (MIP, Average, Min-IP).

With GE's Cine acquisition, the CT images of the MIP dataset are utilized in the treatment planning system. We then select the 4D CT phases corresponding to the 30%~70% breathing phases of the patient.

In our facility, we are using the 4D data and RPM on approximately 10% of patients—those who have stable and reproducible breathing. We have found that 4D CT data aids in assessing the tumor location. Using the GE Advantage 4D with the Varian RPM system has helped us reduce the inner target volumes. The impact on patient treatment since the implementation is impressive. We are able to deliver effective patient treatment with customized treatment plans based on each patient's respiratory pattern. We are experiencing a decline in acute radiation-induced pneumonia rates, which further increases our confidence in 4D treatment planning and ability to effectively irradiate the lesion and spare more surrounding healthy tissue. ■

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Professor He Xiaodong, MD, is the Chief Physicist and Vice Director of the Radiation Oncology Department at Shanghai Pulmonary Hospital. His research of radiophysics, radiobiology, and thermotherapy includes dosage study on EPID; X-ray beam dose distribution reconstruction; electron beam dose calculating model; enlargement of volume effect in LQ model; bioequivalent DVH (BDVH) calculation; RF thermodosage theorem; and portal image processing technique. He is also well known in China for his expertise on moving target radiation therapy.

Shanghai Pulmonary Hospital is affiliated to Shanghai Tongji University (also known as Shanghai Occupational Disease Hospital). The hospital opened in 1933 and the radiation oncology department—dedicated for lung and esophagus cancers and mediastinal and metastatic tumors—was built in 1989. Oncology equipment includes two Linear Accelerators (one with RPM), a set of large aperture 4D CT simulators, one X-ray simulator, and several treatment planning systems.