AbstractID: 4454 Title: Respiratory gated and four-dimensional tumor tracking radiotherapy

Human anatomy and physiology change with time. Solid tumors also exhibit temporal behavior, particularly when assaulted with radiotherapy. In the era of image-guided therapy, technology is being developed to explicitly account for these changes with time, both in cancerous and healthy tissue. One source of temporal anatomic changes is respiratory motion, which affects organs (and tumors) in the thorax, abdomen and pelvis. This motion causes deleterious effects during the imaging, planning and delivery of radiotherapy:

- *Imaging:* Motion causes a misrepresentation of the positions, shapes and volumes of both the tumor and normal anatomy during CT scanning and other imaging modalities. This phenomenon potentially leads to geometric misses of the tumor during treatment delivery.
- *Planning:* If tumor motion is present, and not explicitly being accounted for, larger safety margins are needed. These larger safety margins increase normal tissue dose, increase treatment-related toxicity and limit dose escalation.
- *Treatment delivery:* The motion of the tumor during treatment can cause unplanned under- and over-dosage regions, particularly for IMRT.

Clinical studies have demonstrated evidence of a dose response for both tumors and healthy lung tissue. Thus it is hypothesized that increased targeting accuracy will allow for dose escalation, facilitating improved local control, and/or a reduction in treatment-related toxicities, predominantly pneumonitis. Two methods that can account for respiratory motion and hence increase targeting accuracy are respiratory gated radiotherapy and four-dimensional (4D) tumor tracking radiotherapy.

An implicit assumption common to all techniques that base delivery decisions on the respiratory signal is that the tumor motion is correlated with this signal. The strength of this correlation is dependent on the patient, tumor type and location and the source of the respiratory signal.

Respiratory gating is a method of synchronizing radiation with respiration, during the imaging and treatment processes. Image acquisition occurs either by prospectively triggering acquisition during a certain part of the breathing cycle, or retrospectively sorting the sinogram/images based on the part of the breathing cycle in which they were acquired. Respiratory gating has been successfully clinically implemented in a number of academic and community settings for both conformal and IMRT treatments.

4D radiotherapy can be defined as the explicit inclusion of the temporal changes in anatomy during the imaging, planning and delivery of radiotherapy:

- *4D CT imaging:* Acquisition of a sequence of CT image sets over consecutive phases of a breathing cycle.
- *4D planning:* Designing deliverable treatment plans on 4D CT image sets.
- *4D treatment delivery:* Continuous delivery of the 4D treatment plan throughout the breathing cycle.

4D delivery can be achieved by continuously aligning the beam and patient during treatment using a robotic linac, DMLC, block motion or couch motion.

Educational Objectives:

1. Understand the rationale for accounting for respiratory motion during imaging, treatment planning and radiation delivery.
2. Learn about the clinical implementation of respiratory gated radiotherapy.
3. Learn about 4D tumor tracking radiotherapy.
4. Understand the advantages and disadvantages of respiratory gated and tumor tracking radiotherapy.

Conflict of interest: PI's research supported by Varian Medical Systems.