Image-Guided Motion Management: A Portal to Expanding IMRT Applications

by Calvin Huntzinger

The advantage of IMRT is that, since the radiation beam can be shaped to match the dimensions of a tumor, a high dose of radiation can be delivered to a malignancy without harming surrounding normal tissue.

However, tumors can move, both during a radiation treatment session and from one treatment session to another as a result of normal internal organ action (digestion, elimination, and breathing) and small differences in the way the patient is positioned for treatment. If these changes in position move the tumor out of the planned treatment range, the tumor may not receive the full amount of radiation that it should or normal tissues may receive more radiation than they can tolerate.

The first order of business when delivering an IMRT treatment is accurately locating the tumor, or target, each day. Patient immobilization and positioning techniques in your clinic must be fully understood and under control. The following review article on patient positioning is a "must read": Langen KM, Jones DTL. Organ motion and its management. *Int J Radiat Oncol Biol Phys.* 2001;50(1):265-278.

Using IMRT does not necessarily mean that margins can be reduced. Remember that margins are based on immobilization and repositioning techniques, not dose delivery techniques. Once patient immobilization techniques are mastered, new techniques may then be introduced with the expectation of reducing margins.

Practitioners are using new image-guided techniques to verify the tumor location each day. Ultrasound systems have begun to find their way into the clinic, but they only work well in the abdomen where there are no air cavities or significant amounts of bone. An alternative approach is electronic portal imaging, which requires the placement of small, inert marker seeds in the soft-tissue tumor as an aid to visualization. Yet another technique is to produce a computed tomography (CT) image of the patient using the "cone-beam" technique. The linear accelerator's larger conical beam is used, and the entire 3-D volume can be imaged with just one linac rotation. The cone-beam approach works for either kV or MV X-ray beams, but a kV beam produces the highest image quality using the least amount of dose.

Treating cancer in the lung, liver, or pancreas can be problematic since these organs move with respiration. Practitioners have tried to manage tumor motion by asking patients to hold their breath at a specific point in the respiratory cycle ("deep inspiration breath hold"), allowing them to breathe only when the linac allows ("active breath control"), or using physical restraints that limit the distance the chest can move. Since most patients with thoracic malignancies have limited respiratory capacity and cannot tolerate further reductions in oxygen, patient compliance has sometimes been an issue.

An alternative solution is an automated respiratory gating system that uses an infrared camera to track a passive marker block placed on a patient's chest or abdomen. The system processes the tracked motion to characterize the patient's normal breathing pattern in the form of a respiratory waveform. The data are typically gathered during CT simulation so that the respiratory motion can be synchronized with the CT image acquisition, i.e., "4-D" CT, the fourth dimension being time. During treatment, the system automatically gates the radiation beam on only when the tumor falls within the planned treatment field. Throughout the simulation and treatment processes, the patient can breathe naturally and remain comfortable.

Image-guided IMRT has the potential to achieve both unparalleled tumor control and normal tissue sparing. Achieving image-guided motion management throughout the radiation oncology process requires a series of integrated tools to manipulate all patient data, including images, efficiently and effectively. Clinics that want to use image guidance to manage motion must anticipate the changes that new targeting and planning procedures will make in their daily schedule, and should make sure that the fundamentals of patient immobilization and set up are mastered so image-based target localization can be successfully employed.

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