Intensity-Modulated Radiation Therapy: Taking Aim at Head and Neck Cancer

It's a question of accuracy

By Amy Lemley

Oncologists know that radiation kills cancer cells, but they also know it can damage the healthy organs and tissue near those cells.

In cancers of the head and neck, the proximity of tumors to critical structures such as the eye, spinal cord and brain stem is a special challenge. Radiation can destroy the nearby mandible and the parotid glands, resulting in significant toxicity. A new technology available at UVa Health System, intensity-modulated radiation therapy (IMRT), minimizes radiation exposure to nearby structures while maximizing the dose of radiation a tumor receives.

"Our goal is to achieve a conformal radiation dose," says Paul Read, M.D., Ph.D., a Cancer Center radiation oncologist. "Escalation of tumor dose while decreasing the dose to normal tissues potentially raises the chance of tumor control while sparing normal tissue functioning, resulting in improved quality of life."

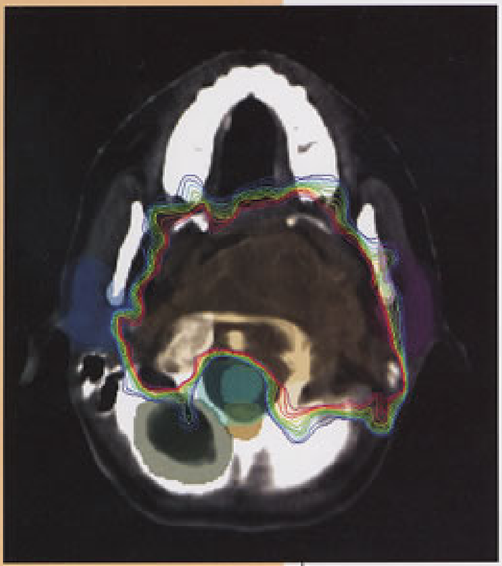
Advances in linear accelerator technology include the multileaf collimator, which allows for radiation-intensity modulation by providing very complex and individualized radiation-blocking patterns. In addition, improvements in sophisticated radiation-planning software allow for conformal radiation therapy, in which high-dose radiation conforms to the tumor to spare normal tissues.

Precise tumor location is critical to conformal therapy. "We used to look under a fluoroscope and use the bony landmarks to map out a patient's radiation fields," Read says. Today, specialists use CT scans with MRI co-registration to define the primary target volume and locate radiation-sensitive structures, creating a computer-generated 3-D patient reconstruction.

That information becomes part of the data used to create what is called an "inverse" treatment plan. "Instead of using standardized radiation fields and blocking for all patients, the treatment-planning computer uses a sophisticated optimization algorithm to determine the multiple blocking arrangements or segments and the radiation dose that should be delivered to each segment and field," Read says.


Jackson Smith

Radiation oncologist Paul Read, M.D., Ph.D., examines an intensity-modulated radiation therapy (IMRT) display. This new technique allows radiation oncologists to determine very complex and individualized radiation-blocking patterns so that radiation can be focused on tumors near sensitive structures.



A computer-generated IMRT plan shows 100 percent to 80 percent radiation isodose lines for conformal treatment of a skull base tumor (brown mass). Because of the multi-leaf collimator, which can focus beams of radiation at several segments and fields, this technology can deliver high-dose radiation to a tumor with relative sparing of critical central nervous system structures.

Despite heavy reliance on technology, "It's still very much a team approach," involving oncologists, radiation therapists and physicists, Read says.

"In radiation therapy in general, no patient is treated without a physicist checking on the treatment plan," says Janelle Molloy, Ph.D., a radiologic physicist. She uses a "phantom" or polystyrene stand-in to double-check that the machine is accurately delivering the proper dosage for each patient.

Molloy also examines film dosimetry "to verify that we are within the tolerances of the critical normal structures," she says, turning to an illuminated piece of film and tracing the gray-shaded checkerboard over a horseshoe-shaped shadow—the brain and the tumor growing near it.

The promise of IMRT's precision is borne out in the performance data Molloy has collected. "I was pleasantly surprised to find that they are accurate within 1 percent," she says. "Inverse treatment algorithms would not be possible without a lot of computing power," Molloy says. "You can't do a hand calculation as you can with regular radiation."

As in regular radiotherapy, the patient must lie completely still on the treatment table for each session. Even a few millimeters of shift could reduce the treatment's effectiveness and threaten healthy tissues or the spinal cord.

Read recalls that when he started in the early 1990s, radiation oncologists used masking tape to help hold patients in place for what were typically 10-to-15-minute sessions. Each IMRT session takes almost twice as long. To help immobilize patients during treatment, each patient is fitted with a special heat-moldable plastic mesh that, once cooled, forms a custom immobilization device suitable for the five-to-seven-week duration of treatment.

For patients who receive radiation therapy, cumulative lifetime radiation exposure can be a serious concern. "The spinal cord and brain stem can only tolerate so much, so we are cautious about that," Read says. "IMRT offers subsets of patients, particularly those who have previously received radiation and who have tumors close to critical structures, the option for retreatment that is not widely available at most centers."

Going to BAT against Prostate Cancer

Intensity-modulated radiation therapy is harder to direct at a moving target such as the prostate, which can shift in position day to day. A new type of ultrasound available at UVa Health System makes it possible to precisely locate and treat prostate cancers without placing nearby healthy tissue at risk of radiation toxicity.

B-mode acquisition and targeting (BAT) is an innovative application that, when combined with IMRT, allows physicians to direct higher doses of radiation at tumors while sparing nearby healthy tissue.

Using an ultrasound probe with a special sensor, physicians can compare a tumor's current position with the linear accelerator target that the treatment plan prescribes. If necessary, the patient can then move slightly to align with the target. The analysis takes just a few minutes and is far more convenient and cost-effective than daily computerized tomography.

Conventional radiation treatment adds an extra 2 to 3 cm of coverage around the prostate, and that buffer region includes healthy tissue. With BAT to guide them, radiation oncologists can reduce that treatment margin to just millimeters—a significant difference that not only spares normal tissue but allows a higher dose of radiation to reach the cancerous area, improving the chances of survival while minimizing side effects.

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