Medical Xpress

Precision Radiation Can Destroy Tumors That Surgery Cannot Reach

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Debora Tisdale didn't want to lose her heart in the process of saving her cancerous breast. She feared that during radiation treatment, the searing beams intended to attack her breast tumor could also inadvertently strike her healthy heart.

"I thought, 'I'm going to live through breast cancer and then die of a heart attack," said 44-year-old Tisdale of Raleigh, N.C. Her family history of heart disease only intensified her worries.

Just a year ago, the state of radiation technologies may have justified Tisdale's fears: radiation was difficult to harness and channel directly to the tumor, and healthy tissue often was damaged during treatment.

But today, scientists in Duke University Medical Center's Department of Radiation Oncology, along with scientists at a handful of other institutions, are providing the medical equivalent of a guided navigation system to irradiate the tumor itself while avoiding healthy tissue nearby.

The new techniques, known as "intensity-modulated radiation therapy" (IMRT) and "image-guided radiation therapy" (IGRT), are so precise that they hit the tumor while barely straying outside its perimeter, said Fang Fang Yin, Ph.D., director of radiation physics at Duke. The technology enables physicians to view the tumor in real time, with a three-dimensional view, as it shifts with the patient's breathing and the motion of nearby organs.

Yin presented new data on Duke's experience using the technologies to treat patients on Monday, Nov. 6, 2006, at the annual meeting of the American Society of Therapeutic Radiology and Oncology, in Philadelphia.

According to Yin, the data show that IMRT and IGRT can reduce the margin of tissue destruction around the tumor from more than a centimeter to less than 5 millimeters. A centimeter is roughly four tenths of an inch, while a millimeter is four-hundreds of an inch.

"We can now target tumors with such accuracy and precision that, in some cases, radiation oncologists need to give patients only one to three treatments instead of two to six weeks of radiation," Yin. "We have designed the beams more intelligently, with much higher radiation to the tumor and sophisticated imaging techniques that allow us to exactingly blast the tumor and avoid healthy tissue."

As a result, patients experience greater tumor shrinkage and faster pain relief, according to the researchers.

Until now, radiation has typically been used to shrink tumors to a more manageable size prior to surgery, or to relieve pain and pressure caused by large tumors. But Yin said the new techniques are so intensive and precise that they now can be applied to "body radiosurgery" -- using highly focused radiation in lieu of surgery to destroy tumors.

Radiosurgery has been applied to brain tumors for quite some time, because the brain is a solid and static organ, Yin said. But the technique has just recently been used to treat tumors in the body, which are continually shifting and are thus harder to target.

"For some patients, we can completely eradicate their tumors using radiosurgery guided by IMRT and IGRT," he said. "This is particularly important for patients who are not appropriate candidates for surgery." Duke was among the first centers in the United States -- and is the only center in North Carolina -- to apply IMRT and the latest IGRT techniques to body radiosurgery, he said.

The precision aim offered by the new technologies is crucial to patients with all types of cancer, said Yin, because most tumors arise from or sit adjacent to vital organs or tissues, whose destruction would compromise important bodily functions or reduce the patient's quality of life.

For example, breast cancer patients are susceptible to lung damage as well as heart damage, and prostate cancer patients may develop impaired urinary and rectal function.

For her part, Tisdale said her treatment led to none of the usual side effects, from damaged heart tissue to burned skin.

"I didn't have any burning, and my test results show that my heart is in excellent condition," she said. "I felt like they were really able to pinpoint my tumor exactly. In fact, they showed me X-rays of each treatment after the radiation therapy was done, and the images were so exact in zeroing in on the tumor that they looked like mirror images of each other," she added.

Precision aim is also vital to patients with head and neck cancers, who risk damaging or losing their ability to taste, smell, swallow, breathe and talk. IMRT and IGRT dramatically improve the ability to spare the parotid glands, which produce saliva, said David Brizel, M.D., professor of radiation oncology.

"Imagine chewing food or speaking without the ability to produce saliva," he said. "Until you lose something, it is hard to understand how important a role it plays in your daily life."

While treatment with the new technologies appears seamless to the patient, the techniques are so complex that they require an integrated effort involving physicists, radiation oncologists, dosimetrists, and therapists to successfully orchestrate, said Lawrence Marks, M.D., professor of radiation oncology.

Intensity-modulated radiation therapy uses powerful "linear accelerators" to dramatically enhance the energy level of the radiation beam. The high-energy beams pass through a series of lead shutters, called collimators, which guide and tilt the beams at various angles so they conform to the shape and size of the tumor. Computers direct the collimators to move in and out of the beams' path to provide more radiation to the tumor and less to the normal tissues.

"We turn off specific parts of beams that might damage healthy tissue," Marks said. "Each treatment field has hundreds of small beams within it, each with its own intensity. We vary the intensity from one beam to the next so that normal tissues are spared."

The huge radiation machine conjures images of a carnival ride, as it literally rotates around the patient. When the patient breathes, a chest monitor senses the movement and the beam automatically turns on and off in order to reduce the dose to the lungs. Likewise, if the tumor moves out of the treatment field, the beam turns off. Each measure is designed to diminish the radiation fallout to healthy tissue, Marks said.

The companion technique that Duke offers, image-guided radiation therapy, combines two imaging methods – X-ray and cone beam CT -- to give the treating physicians three-dimensional, real-time images of the tumor so they can better visualize its size, shape and proximity to vital organs.

With conventional radiation treatment, doctors obtain an image of the patient's tumor several days or weeks prior to treatment using a device called a computed tomography (CT) scanner. When treatment begins, doctors manually position the radiation beams according to that CT image. But matching the image to the patient is imprecise, because the patient's position subtly shifts from the CT scanner to the radiation table. As a result, doctors get a general idea of the target's location, but their uncertainty requires them to irradiate a large margin around the tumor to secure the target. Such limitations prohibited the use of techniques that delivered high-dose radiation to the tumor.

Using IGRT, doctors can instantaneously image the tumor each time the patient lies down for radiation treatment, because the scanners are built into the linear accelerator itself. Physicians immediately compare these images to the previous diagnostic images to ensure accurate placement of each beam. Moreover, the cone beam CT provides a three-dimensional image of the tumor, so its depiction is more accurate and precise than with traditional, two-dimensional CT.

"X-rays see the bony structures and CT provides clear contrast between soft tissue and bony structure, so the combined images depict the tumor's locale and its relationship to nearby organs, bones, glands and other critical structures," said Nicole Larrier, M.D., associate in the department of radiation oncology.

Before a single beam is released, physicians meticulously outline the location of the tumor, the organs to protect and the radiation dose. The medical physicists simulate the proposed treatment by integrating all of the images and data into a computer mock-up. The team reproduces, verifies and adjusts the beams as needed to ensure the treatment progresses according to plan.

Such protective measures mean that physicians can nimbly change treatment to meet changing conditions, said John Kirkpatrick, M.D., Ph.D., assistant professor of radiation oncology.

"The real-time on-board imaging allows us to refine the treatment plan mid-way through a course of treatment to adapt to changes in the tumor's size," Kirkpatrick said.

"The end point is, how much normal tissue can we spare while attacking the tumor with the greatest intensity needed to kill the tumor cells," said Christopher Willett, M.D., professor and chairman of the department of radiation oncology.

Source: Duke University Medical Center

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