

A BOARD-CERTIFIED PHYSICIST IN RADIATION THERAPY

When Wilhelm Roentgen serendipitously discovered x rays in his University of Würzburg laboratory in 1895, he unknowingly took the first step in what has become a continuous association between the physics and medical communities. Beginning with x rays, physicists have been in the forefront of figuring out medical uses for radiation, from diagnostic imaging to radiation therapy of tumors. Roentgen himself received the first Nobel Prize in Physics as well as an honorary medical degree from Würzburg University.

Dan Bourland, an assistant professor of radiologic physics at the Mayo Clinic in Rochester, Minnesota, is part of this medical physics tradition. With a 1990 PhD in radiological hygiene (more commonly known as health physics) from the University of North Carolina, Chapel Hill, Bourland brings the expertise of the physicist into the world of clinical medicine. Not an MD, he cannot prescribe radiation treatments for patients, but in almost every other aspect of the planning and execution of radiation therapy, he and medical physicists like him play a key role.

"The bottom line in therapy," Bourland explains, "is to treat the tumor with the maximum dose and give the minimum dose to normal tissue. If the tumor were floating in midair, it would be great; we could irradiate it with no problem." A common method of dealing with this situation is to irradiate the tumor with multiple beams, which are positioned to overlap so that the tumor receives an approximately uniform dose of radiation.

The concept that bridges his clinical and research work is three-dimensional treatment planning. In the clinical setting, this means the use of fully three-dimensional diagnostic images obtained from magnetic resonance images, computed tomography scans or some other imaging technique to determine the tumor location as accurately as possible. If ra-

diation is required for treatment, this information is then fed into an appropriate computer program to calculate the dose delivered to each point in the tumor and surrounding area for a given irradiation geometry.

In contrast to the newer three-dimensional technique, the standard two-dimensional treatment-planning methods calculate doses only in a single plane containing the irradiating beam; no information is available about the radiation's effect outside the plane. Limiting information to two dimensions makes it necessary to confine multiple radiation beams to the same plane, which can make it difficult to avoid those normal structures that are best left untouched by the treatment.

With the three-dimensional technique, Bourland and the physician work together to determine the exposure parameters (beam location, energy, intensity, duration and so on) for optimal treatment. "We have been using three-dimensional treatment planning at Mayo for about 16 months now," says Bourland. "So far we have treated 100 patients, mostly those with brain tumors."

The often irregular outline and sometimes diffuse nature of tumors provide much of the motivation for seeking new imaging and treatment modalities. A technique called stereotactic radiosurgery, which makes use of high-energy x rays from a linear electron accelerator, illustrates one limitation of the current state of the art. In this technique, small lesions in the head are treated with a narrow (one to four centimeters wide) continuous x-ray beam, which is emitted by an accelerator that rotates around the stationary target. As the beam source moves through a series of crisscrossing arcs over the patient, it creates a roughly spherical irradiated volume within which the dose is very high and outside of which the dose drops very quickly.

"This approach is okay if the tu-



Dan Bourland

mor is spherical, but it's not so good if the tumor is irregular, because then we are irradiating normal tissue," Bourland observes. For real tumors, which are often aspherical and may be very large, he and his coworkers at Mayo are taking a look at multiple static x-ray sources aimed at the target from different angles in a hemispherical geometry. This technique requires three-dimensional dose calculations. Each beam is masked by a thick lead-alloy cutout that matches the shape of the tumor as seen by the beam.

Although he characterizes this project and others he is involved in as long-term, Bourland views them from a clinical perspective; they are not academic-style basic research. "We have promising data for the multiple-beam technique, including computer simulations of treatments of test targets," Bourland says. "This technology is scheduled to make it to the clinic early next year, and the doctors at Mayo want to use it as soon as it's ready."

Despite Bourland's present enthusiasm, developing new technology to cure sickness and alleviate suffering

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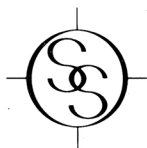
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only gradually made it onto his career agenda. Attending a small high school where many youngsters had farming or a trade written in their futures, he was one of the few looking forward to college. During a severe attack of the senior blahs, an encounter with a benevolent but strict physics teacher helped put him back on track. "The teacher got my attention. I really wanted to go to college, and [she showed me that] I could do better." Although he also had a strong interest in music and played drums in a garage band, the physics experience turned him toward a technical career and a physics major at the University of North Carolina.

Bourland's career aspirations became clearer during an extended visit to Argonne National Laboratory during his senior year in college when the laboratory was celebrating the 35th anniversary of the first Chicago reactor. He developed an interest in things nuclear but also came to the realization that he preferred working directly with people rather than in a laboratory. After briefly considering the Peace Corps upon graduating in 1978, he enrolled in a two-year radiological hygiene program in the School of Public Health at Chapel Hill.

As a graduate student, Bourland worked on a project at nearby Duke University, where he became interested in radiation therapy of cancer patients. After completing that program, he wanted to continue to the PhD level in radiation therapy, but a dearth of opportunities stalled his ambition for a time. However, by 1983 he found himself back at Chapel Hill pursuing doctoral studies in radiological hygiene. It became a lot easier when his wife, Beth, who has a master's degree in special education, found a position developing curriculum materials at the Frank Porter Graham Child Development Institute at Chapel Hill.

While pursuing his PhD, Bourland worked part time on a project investigating hyperthermia treatment of cancer, which involved the use of microwaves to heat tumors to about 5.5 C above normal body temperature. Some tumor cells are killed directly by the high temperature, while others are made more sensitive to ionizing radiation, which is applied within a half hour of the heat treatment. This project provided Bourland with an in-depth exposure to the clinical world. "I measured heating patterns and carried out the treatments, which required me to sit with the patient for an hour and a half. I think I did everything except insert the invasive temperature probes,

which only physicians could do."

Bourland's dissertation topic was an investigation of the use of finite-sized pencil beams, a computational technique for calculating three-dimensional dose distributions in which the actual beam is represented by a superposition of many small beams, each with a square cross section and the same dose distribution. The hope was that this method would combine the benefits of a good physical model with the speed of less accurate two-dimensional methods.

By the end of his student career, Bourland had reached the status of clinical instructor in the university's division of radiation oncology. His training and experience enabled him to pass an American Board of Radiology examination and be certified in therapeutic radiological physics. At present, board certification is not a requirement to work as a medical physicist, but it does provide evidence for the capability of the physicist. "The medical physicist is responsible for the performance of the radiation source, including dose measurements and dose calculations. An overdose causes morbidity, while an underdose effects no cure. You have to be able to sign on the dotted line," is the way Bourland puts it.

Bourland says that the current shortage of medical physicists, including those working in diagnostic radiology and nuclear medicine, as well as therapeutic radiology, may end soon. However, clinical training for young medical physicists is still an important need. The American Association of Physicists in Medicine, a 3400-member professional organization whose purpose in part is to encourage training in medical physics and related fields, accredits graduate programs at both the MS and PhD levels and maintains a list of training programs.

"I'm a kind of generalist," Bourland concludes. "Besides my research projects, I look at x rays with physicians to determine if the patient is a candidate for three-dimensional treatment planning, and I participate in calibration and quality assurance of the radiation machines. A part of my job that gives me great satisfaction is that I teach in the Mayo medical and graduate schools and advise students."

Bourland believes that mentoring in medical physics is important. "During my career I have been very fortunate to have trained and worked with excellent medical and health physicists, who taught me physics and modeled for me the practice of medical physics."

—ARTHUR L. ROBINSON ■