David W. Roberts, M.D.: Neurosurgical navigator

By Jennifer Durgin

Grew up: Kingston, N.Y.

Education: Princeton University '72 (A.B. in English); Dartmouth Medical School '75 (M.D.); Oxford University (M.A. in English)

Training: University of Utah Medical Center (general surgery); Dartmouth-Hitchcock Medical Center (neurosurgery)

Unusual interest: Old maps

First map he bought: An 1848 map of the American West

Why he has never left Dartmouth: "It's the perfect environment for research and development."

In the early 1980s, Roberts and colleagues created one of the first frameless stereotactic neurosurgery systems.

"You're going to love this," says Dr. David Roberts, the chief of neurosurgery at DHMC. He's addressing the few people in the operating room who have never seen the procedure he's about to perform.

A nurse helps him move a refrigerator-sized surgical microscope into place. Then Roberts peers through the scope's eyepiece inside the skull of the patient—a woman—who is asleep on the operating table. She's almost entirely shrouded in blue drapes, with only a small area behind one of her ears exposed.

For the past hour, Roberts and a fourth-year medical student have been working to remove a piece of her skull so they can gain access to her trigeminal nerve. They've made a small hole, through which they're now able to see where the trigeminal nerve meets the brain. The anatomy of this region is "spectacular," says Roberts, like gazing into a "Gothic cathedral."

The trigeminal nerve carries sensations from the face to the brain. When it's irritated, as is the case for this patient, even a sensation as mild as a breeze can be excruciating. The most common cause of the condition, known as trigeminal neuralgia, is a blood vessel bumping against the nerve. In such cases, the surgeon simply lifts the artery off the nerve and inserts a tiny pad to keep the two from touching.

As Roberts and a surgical resident peer through the scope's eyepieces, they use a tool that looks like a miniature metal shoehorn to shift the nerve from side to side, searching for an artery that may be touching it. "You really need to look all the way around the nerve," Roberts tells the resident. "Sometimes you'll look and see nothing. . . . Then you'll look again, and there it is."

But neither of them can find an offending artery. Roberts is visibly disappointed. The only other option to relieve this woman's pain is to partially sever the nerve, he explains. She's a "poor candidate" for that procedure because some of her pain is near her eye. Cutting the part of the trigeminal nerve that branches into that region of the face could have the unwelcome side effect of disabling her blink reflex. "But that's the best treatment option she's got," says Roberts.

So he and the resident delicately try to clip just enough, but not too much, of the nerve. As they work, Roberts quizzes the resident and the medical student about nerve anatomy and various aspects of the procedure, but his style is relaxed, not interrogative. It fits well with his Nike sneakers and Yankees surgical cap. Some surgeons make their presence known in the OR with a booming voice and a take-charge attitude. Roberts, on the other hand, acts more like a member of the team. Yet it's clear that the trainees, nurses, technicians, and other staff respect him and are eager to learn from him.

"He's a good teacher," says OR nurse Candace Colby-Collier, since he often stops and explains what he's doing or seeing.

"He does classic neurosurgery, like you would read [about] in a book," observes scrub tech Martha Irvine. She has one of the best views in the OR because she stands right next to the surgeons.

Roberts's approach to neurosurgery may be "classic" in the sense that it is precise and consistent, but it's anything but stagnant or old-fashioned. Throughout his career, he's worked to develop high-tech ways to help surgeons better navigate within the brain.

A central challenge of neurosurgery is how to translate two-dimensional images, such as x-rays or magnetic resonance images (MRIs), into the real-time, three-dimensional anatomy that the surgeon faces in the OR. For much of the 20th century, neurosurgeons mediated this problem with stereotactic frames. These cumbersome metal frames were clamped to patients' heads during imaging and then throughout the surgical procedure. The frames provided points of reference between the x-rays and the surgical field. Measurements on the frame were used to assign coordinates to an abnormality visible on the x-ray. Then, in the operating room, the coordinates helped the surgeon know where to look for the abnormality and where cut.

Stereotactic frames were popular for treating some neurological conditions until about the 1960s, when new medications made surgery unnecessary or undesirable. By the time Roberts was a resident, in the early 1980s, there were no training programs in the U.S. still using stereotactic frames.

Yet Roberts had been interested in stereotaxy since he first read about it as an undergraduate. As a neurosurgery resident at Dartmouth, he was eager to learn more. He became convinced that stereotactic principles could and should be adapted to modern brain surgery, because otherwise a surgeon "would look at the x-ray on a view box and then . . . fly by the seat of his pants—[and] usually it was *his* pants," says

Jennifer Durgin is the associate editor of DARTMOUTH MEDICINE *magazine.*

Roberts. "You don't have to see too many cases where somebody is searching through the brain . . . to say, 'There's got to be a better way.'"

So Roberts traveled to the Karolinska Institute, a top academic medical center in Sweden, to get training in stereotactic techniques. "A few centers in Europe [had] kept the art alive," he says. It became obvious—at least to him—that "stereotactic principles were ready to explode." The advent of computers would totally transform stereotaxy and the way neurosurgery was done, Roberts predicted.


JON GILBERT FOX

David Roberts, chief of neurosurgery at Dartmouth, is quiet-spoken but an international force in developing technologies to ease the navigational challenges of brain surgery.

When he returned to Dartmouth from Sweden, Roberts immediately shared his ideas with John Strohbehn, Ph.D., who at the time was a professor at Dartmouth's Thayer School of Engineering. "I got John interested," says Roberts. Their investigations "just took off."

During the early 1980s, Roberts and Strohbehn, along with students, postdocs, and other faculty, created one of the first frameless stereotactic systems. The idea was that a computer could integrate images with the surgical field much better than a metal frame. Like a global positioning system (GPS), which allows people to know where they are in relation to a map, frameless stereotaxy helps surgeons know where they are with respect to a patient's CT scan or MRI.

In hindsight, it may seem obvious that frameless stereotaxy was worth pursuing. But at the time, Roberts says, "we had people—particularly people who had vested interests in frames—telling us, 'This is stupid. Why would you do this?'" But it wasn't long before the project attracted attention. Eventually, "we had people coming through every week or every month from all over the world who were interested in this," recalls Roberts. Soon other research groups were developing frameless stereotactic systems. By the 1990s, the technology had matured and private companies were involved. "You had a zillion of these systems—everybody and their uncle creating them," says Roberts, until the "industry coalesced into a handful of players."

By then, Roberts's interests had moved on. He and his Thayer collaborators had turned their attention to another problem neurosurgeons face: the changing geometry of the brain during surgery. Using the GPS analogy, Roberts explains that GPS devices rely on maps made at a particular time, perhaps a week or a year ago. "Roads don't move around a whole lot," he points out. But the brain is soft tissue, and it sags during surgery as cerebrospinal fluid drains out and gravity deforms the organ's usually buoyant shape. This means the "maps"—the images (usually MRIs)—quickly become out of date. "At that point, you could either stop using [the images] or you could put an MRI scanner in the operating room itself . . . and just get a new map." Roberts calls that the "brute force solution." It's what a lot of medical centers do today, he says.

"Or," he goes on, "you could get clever" and apply a computational solution. "These aren't mutually exclusive" approaches, he adds. "You could have some hybrid models."

For almost 20 years, Roberts has been working with engineer Keith Paulsen, Ph.D., and others at Thayer to develop systems that can integrate data from different types of images and still adapt to the real-time surgical field. Roberts says this approach is especially useful for neurological conditions that don't show up on an MRI, which is often the case, for example, with epilepsy. "And most centers wouldn't be able to do anything. They'd [tell the patient], 'You're just not a surgical candidate.'"

The Dartmouth approach is to collect data not just from an MRI but also from other technologies, such as EEG (electroencephalography) and PET (positron emission tomography). The systems Roberts and his colleagues are developing allow them to do surgeries that would otherwise be "very difficult," he says, or "maybe even impossible" to perform. (To learn about another technology Roberts is working on, using fluorescence, see **dartmed.dartmouth.edu/w08/v02**.)

Roberts has such a passion for the intellectual challenges of his field that it's easy to forget about the compassion that he shows toward his patients. "The thing about neurosurgery is that nearly every patient we encounter is at a highly important point in their life," he says. "Maybe they have a brain tumor. . . . They could emerge from the [surgical] encounter with a new lease on life. Or maybe they're going to find out that they have something really bad." For all the high-tech gadgetry of neurosurgery, "it's a people thing," says Roberts. "And the day it is no longer," he asserts, "you shouldn't be in it."

So how did things turn out for the patient suffering from trigeminal neuralgia? Her pain is gone and her blink reflex remained intact. "Oh, she was a home run!" Roberts exclaims. ■