Moving to Recovery

A PIONEERING DOCTOR WHO TREATED CHRISTOPHER REEVE SAYS EXERCISE MAY BE THE WAY TO FIGHT PARALYSIS

Dr. John McDonald wore a satisfied expression as a 21-year-old patient, paralyzed from the neck down in a diving accident, walked on a slow-moving treadmill.

It wasn't walking as most people know it. Without electrodes firing his weakened muscles, the patient's legs would barely move. Without two therapists physically placing one foot in front of the other, he would likely stumble. And without a body sling suspended from above, he would surely fall.

To McDonald, recruited in 2005 to head a spinal-cord injury program at Baltimore's Kennedy Krieger Institute, there is nothing futile about exercising limbs that can barely move on their own.

The 43-year-old neurologist says his work with the late actor Christopher Reeve demonstrated that exercise might hold the key to something scientists long considered impossible — reactivating neural pathways that have been silent for years.

"In this new world, the nervous system is much more capable of change than we ever thought," McDonald said in a characteristic burst of enthusiasm. "Old ideas are starting to fade away."

McDonald arrived in Baltimore with a treatment team from his former base, Washington University in St. Louis. It was partly on the strength of his work there with Reeve that Kennedy Krieger hired him to elevate its spinal cord program, which lacked the national reputation of its programs in autism, cerebral palsy, lead poisoning and other neurological disorders.

"We weren't pushing the frontier to make [the condition] better," said Dr. Gary Goldstein, president and chief executive officer.

Goldstein, who remembered McDonald as a bright young medical student at the University of Michigan, offered him an arsenal to enhance his efforts to get paralyzed people moving again: support for stem cell research, collaboration with neighboring Johns Hopkins and the latest imaging technology. It also promised an ideal patient profile, heavy on children whose still-developing nervous systems may stand to gain the most.

Photo: Courtesy of the Kennedy Krieger Institute

"In this new world, the nervous system is much more capable of change than we ever thought."
—John McDonald

Exercise is the core of McDonald's program. It is based on the theory that repetitive activity can awaken the spinal cord to grow new cells, sprout connections and direct movement independently of the brain.

In the institute's new rehabilitation gym, patients are helped onto stationary bikes and hooked to electrodes that cause their leg muscles to contract. Some work out on treadmills, aided by electricity and therapists.

With boyish looks and irrepressible optimism, McDonald has become one of the most visible and charismatic proponents of activity-based therapy. But the idea wasn't his alone. In the 1930s, nurses tried in vain to restore movement to polio victims by forcibly moving their limbs and encouraging them to float in pools. The strategy didn't work, McDonald says, because it addressed the wrong disease. Polio destroyed neurons along the spinal cord, damage too diffuse to benefit much from exercise.

In contrast, a spinal injury damages a narrow band of spinal issue, disrupting the flow of signals from the brain to the places below the injury. Similarly, information gathered in the extremities has no way of crossing the breach to reach the brain, which is why patients lack sensation in affected areas.

But what if the spinal cord had its own mini-brain that played a role in directing movement? For decades, biologists uncovered some evidence of that in a collection of cells at the base of the cord that helped control rhythmic movements such as walking and cycling.

The region, called the pattern generator, was identified in locusts and lampreys as well as cats and rats. Then, in 1991, a Canadian scientist demonstrated that a cat whose spine was crushed could learn to walk again if trained, raising the possibility that forced movement retrained the pattern generator to act on its own.

Though scattered doctors started testing repetitive exercise in their patients, McDonald said the idea came to him when he was assigned to Washington University's rehabilitation unit in the mid-1990s. There, he watched patients learning to maneuver wheelchairs and feed themselves with long, curving forks and spoons. Therapists were earnestly helping people prepare for life at home, yet something seemed amiss.

McDonald's program is based on the theory that repetitive activity can awaken the spinal cord to grow new cells, sprout connections and direct movement independently of the brain.

"All of a sudden, it was like a light bulb went on," he said.

Nobody was encouraging the patients to exercise, which everyone knew promoted a strong heart, bone density, healthy skin and muscle mass. Beyond the obvious health benefits, he thought, movement might also reactivate the pattern generator.

McDonald said the potential of exercise to spur recovery didn't become clear until he met Reeve. The actor who had soared to fame in Superman movies became paralyzed the instant his head hit the ground in a 1995 equestrian accident.

"He was the most motivated individual I ever saw," McDonald said. "I was surprised to find that he was working his tail off to do as much as he could, but nobody was helping him. I'd say, 'Chris, I know we can help you.'"

Reeve, who became McDonald's patient in 1999, worked out on a stationary bike three times a week, with wires attached to his legs and buttocks. Therapists helped him move his legs in a pool and, as his strength increased, urged him to push against the wall.

Two years into the program and six years after his injury, Reeve was able to move one wrist and some of his fingers and toes. He could feel a pin prick nearly anywhere and detect degrees of hot and cold. Later, said McDonald, he could tap fingers on command — index, ring, pinky.

Though Reeve never walked again, dying in 2004 of a bloodstream infection, his was the first documented case of a complete quadriplegic regaining function so long after being injured. Dr. Oksana Volshteyn, a St. Louis neurologist who worked alongside McDonald, said he brought a sense of possibilities to the unit.

"Everything in his mind is doable regardless of situation or resources," she said. "If we needed to work at night, we'd work at night."

McDonald recently completed a study that compared 30 people who received activity-based therapy with an equal number who did not. Though he declined to discuss the results before publication, he hinted that they will be encouraging.

Exactly what's going on biologically with patients is open to question. Scientists speculate that activity may do more than trigger the pattern generator — that it may strengthen slender connections in the spinal cord that survived injury.

While acknowledging that he is part of a growing movement, McDonald says he has a grander vision. Cycling and other repetitive movements, he says, may actually spark the regeneration of nerves, a process that may take years to achieve. It may also prime the body to benefit from a future stem cell treatment.

"What we say is this — there is hope," he says. "We don't remove the hope."

—*Jonathan Bor*

John W. McDonald completed the Medical Scientist Training Program at the U-M Medical School, earning his Ph.D. in 1991 and his M.D. in 1992. In addition to his work at the Kennedy Krieger Institute, he also holds a primary appointment as associate professor in the Department of Neurology at Johns Hopkins University School of Medicine, with co-appointments in the Physical Medicine and Rehabilitation and Neuroscience departments.