climate that says we think this is something you should do," said Hendin.

• Hospitals should implement programs that train medical students and physicians to recognize depression in themselves, colleagues, and patients.

• Medical schools and hospitals should work with insurance companies to develop in-house consultation, referral, and treatment services for students and residents with mental health problems.

• Data on treatment services offered to medical students and residents with mental health problems should be collected.

• Decisions about physician licensing and credentials should be based on professional performance, not psychiatric treatment or diagnosis.

• State wellness programs should address the needs of physicians who are depressed, but not necessarily abusing substances.

• Physicians applying for insurance should be informed of their rights, privileges, and obligations regarding disclosure of a psychiatric diagnosis and/or treatment.

The group said that for all of these recommended measures, model programs at hospitals and medical schools should be identified and publicized, and noted that much more research is needed concerning the scope of the problem on all levels. □

Rehabilitation Medicine Welcomes a Robotic Revolution

Rebecca Voelker

CHICAGO—Physical therapist Ela Lewis, MSPT, is about to do something that would be considered a grave error in any other setting. Her patient, a 65-year-old man, was left with impaired balance and walking ability after a stroke 10 years ago. To challenge his sense of balance Lewis throws a ball toward her patient, just outside his reach.

Many similarly impaired individuals would fall if they tried to catch the ball; others wouldn't attempt to catch it for fear of falling. And no responsible therapist would ever risk injuring a patient. But Lewis and her patient are demonstrating a novel robotic device that keeps him upright and allows his therapist to use exercises that otherwise would be unthinkable.

The 500-pound device, called the KineAssist, is a motorized platform, or "buggy," with a "smart brace" that supports the trunk and pelvis to help patients recovering from a stroke or other neurological conditions learn to walk and balance their weight again. It is part of an evolution in robotic devices intended to ease and speed patients' recovery and, at the same time, push rehabilitation medicine toward the ultimate question of how far machines can go in reproducing human abilities.

USER-FRIENDLY ROBOTS

Dozens of devices, including the KineAssist, a thought-controlled myoelectric prosthetic arm, and a robotic

Chicago PT, LLC

The KineAssist, a novel robotic device, challenges patients who are recovering from stroke or other neurological conditions while reducing the risk of injuries.

nurses' aid that helps patients perform breathing exercises after cardiac surgery, were described or demonstrated during the International Conference on Rehabilitation Robotics (ICORR), hosted in June by the Sensory Motor Performance Program of the Rehabilitation Institute of Chicago (RIC). The demonstrations showed that robots have been transformed from workhorses in the assembly of large, heavy industrial machines to precision tools tailored for use with patients undergoing rehabilitation.

"The field of robotics has changed," said William Z. Rymer, MD, PhD, the John G. Searle chair and director of research at RIC. "We now have a generation of smaller, portable, more human-friendly devices."

Going beyond the marvel of "bionic" limbs and microelectrodes implanted in the brain's primary motor cortex that allow a patient with tetraplegia to move a computer cursor by imagining the movement, many of the new devices have more practical, therapeutic applications. They are aimed at getting patients who are recovering from a stroke, spinal cord injury, or other neurological disorder back on their feet or able to perform activities of daily living more easily and quickly.

Recovery from stroke is a particular focus in therapeutic robotics research. The number of noninstitutionalized US stroke survivors increased by more than 50% from the 1970s to the 1990s (http://www.americanheart.org/downloadable

/heart/1110821284902FS08OLD5.REVDOC.DOC, Munter et al. *Stroke*. 2002;33:1209-1213). Stroke is also a condition more prevalent among older populations—71% of patients discharged from US short-stay hospitals with a primary diagnosis of stroke in 2002 were 65 years or older. With aging populations in the United States and elsewhere, the number of stroke survivors will almost certainly increase. But aging isn't the only trend driving therapeutic robotics research.

"Three major revolutions in the last 2 years have made therapeutic robotics and the study of therapy with robotic devices a big deal," said James Patton, PhD, co-director of RIC's Robotics Lab. First, recent research has demonstrated that repetitive exercise, when properly performed, is medically beneficial for patients recovering from a stroke. Second, said Patton, the realization that the brain can form new neural pathways as a way of adapting to deficits from stroke or other disorders has opened new doors in rehabilitation robotics.

"Robots are very good at encouraging the nervous system to recover and to recover faster than maybe [it] would with just standard practice," Patton explained.

Last is new technology that has resulted in lightweight, low-cost devices that can operate in a "passive" mode to prevent injury. That feature was evident during the KineAssist demonstration. As the patient reached for the ball, a trunk and pelvis support mechanism allowed him to lean forward, swing to his left, and make the catch without falling. Despite the device's heft, it easily moves forward, backward, and sideways in response to a patient's movements.

Therapists can use the KineAssist to help patients regain walking ability, correct their posture, or as a strength training device. It was developed as a tool, not as a replacement for therapists. Because it eliminates the fear of falling, the device's developers say therapists can focus more attention on patients' exercises.

"We can really challenge patients with this device," said David Brown, PhD, an assistant professor of physical therapy, human movement sciences, and physical medicine and rehabilitation at the Northwestern University Feinberg School of Medicine, Chicago. Brown also is a co-founder of Chicago PT, LLC, which was formed by a group of Northwestern University faculty to develop technology that can help physical therapists improve patient care and safety. The company developed KineAssist, and Brown has the patent on the device.

ONE OF A KIND

The KineAssist prototype demonstrated during ICORR is the only one in existence. RIC put it into use in early 2005, and to date, 10 patients have worked with it. Approval from the US Food and Drug Administration is pending. Controlled clinical trials are being planned, but Brown said he and his colleagues currently are determining best practices for the device.

KineAssist is intended for use in patients who have at least partial ability to walk. But in the early stages of recovery when patients cannot walk, therapists at RIC and other rehabilitation centers in the United States and Europe have begun using a device introduced in 2001 by researchers at Balgrist University Hospital in Zurich, Switzerland, and Hocoma Inc, a medical engineering company in Zurich. This device, called the Lokomat, uses a harness to suspend the patient over a treadmill. Computer-controlled motors at each hip and knee joint move the legs in a preprogrammed gait pattern. Software monitors the movements so patients maintain that pattern.

Traditionally, patients with paralysis have relied on therapists to manually exercise their legs in walking motions. Because the work is exhausting for therapists, such sessions sometimes last only 10 minutes. But researchers believe longer sessions with the automated Lokomat could improve outcomes. In a recent study of 20 patients with impairments from incomplete spinal cord injury, automated therapy given 3 to 5 times a week for up to 45 minutes per session for 8 weeks significantly improved their walking speed and endurance (Wirz et al. *Arch Phys Med Rehabil*. 2005; 86:672-80).

New data from researchers at Northwestern University and RIC that was presented during ICORR examined the impact of Lokomat therapy on ankle joint movement in 5 patients with incomplete spinal cord injury. The patients received therapy 3 days a week for up to 30 minutes per session for 4 weeks. Therapy resulted in significantly reduced reflex stiffness and improved range of motion. Despite the small sample, Rymer said the results compare "favorably" with traditional manual therapy.

Smaller devices that concentrate on improving movement in joints of the arms and hands are another important area in therapeutic robotics. In the last decade and a half, researchers at the Massachusetts Institute of Technology (MIT), Cambridge, have developed robotic devices that help patients regain arm movement and the ability to reach. Their MIT-MANUS robots have been used in clinical trials with more than 250 patients.

MIT-MANUS has a brace that holds the patient's lower arm and wrist while the fingers grasp a handle-like controller mechanism. A video screen prompts the patient to use the controller to do an exercise such as connecting dots or drawing the hands of a clock on the screen. The robot provides whatever amount of arm movement the patient needs to do the exercise. Clinical trials have shown that patients who used the robot had twice as much improvement in their shoulder and elbow movements as controls (Volpe et al. *Curr Opin Neurol*. 2001;14:745-752).

However, shoulder and elbow improvements did not extend to the wrist and hand. The result was that patients could reach for an object but were not able to grasp it. "Wrist control is a key component in grasping . . . because it orients the hand," said Steven Charles, a doctoral candidate in mechanical and medical engineering at the Harvard-MIT Division of Health Sciences.

Charles and his colleagues have developed a number of new video games designed to exercise more degrees of freedom in wrist movement. Their ongoing study, aimed at examining the effects of combined shoulder-elbow and wrist therapy and the sequence in which they are delivered, will enroll 160 patients who are at least 6 months into recovery from a stroke. During an ICORR presentation of preliminary results from 5 patients, Charles said combination therapy improved shoulder and elbow movement by 10% and wrist and hand movement by 28% after 12 weeks of therapy. "The improvements are obvious," he said.

By designing robots that exercise different muscle groups and joints in different parts of the body, MIT researchers advocate the development of a "robotic gym" that can target therapy not only to the arms and legs, but also to the ankles, wrists, and hands for optimal outcomes.

ETHICAL ROBOTS

As robotic devices increasingly make their way into clinical settings, experts at the ICORR meeting talked about the ethical ramifications of viewing robots in the context of human augmentation. "As soon as these [myoelectric prosthetic] arms get to the point where they are better than your physiological counterpart, that's when things will get to be very interesting," said Richard Weir, PhD, a research assistant professor in physical medicine and rehabilitation and biomedical engineering at Northwestern University.

Unlike augmentation through the use of anabolic steroids, robotic devices eventually could have some degree of autonomous behavior to produce sequences of movement, said Neville Hogan, PhD, professor of mechanical engineering and brain and cognitive sciences at MIT. In that event, he questioned how human will or individual decision-making could be separated from the actions of a robotic device.

"We should consider the implications of misuse," added Paulo Dario, PhD, professor of biomedical robotics at the Scuola Superiore Sant'Anna, Pisa, Italy. "Some communities, especially in Europe, are very sensitive to this kind of augmentation. It really goes to anthropological issues and the value you attribute to human beings." □

Interest in Inhaled Insulin Grows

Richard Trubo

SAN DIEGO—Is the era of insulin injections for patients with diabetes drawing to a close? Probably not, at least not yet. Even so, some researchers exploring alternative delivery systems believe that inhaled insulin is now on the fast track and could emerge as a viable, noninvasive avenue for administering insulin.

For more than 80 years, patients with type 1 and type 2 diabetes have relied on subcutaneous injections as the route for exogenous insulin administration. But inhaled intrapulmonary delivery of insulin appears to be a promising option and perhaps a way to maintain glycemic control without the need for injections before meals. Although inhaled insulin is not a new idea—it was first suggested in the 1920s—encouraging findings from recent studies, including phase 3 trials, captured considerable attention at the American Diabetes Association's (ADA's) 65th Scientific Sessions here in June. At a symposium on new insulins, Jay S. Skyler, MD, noted that at least one pulmonary insulin system is now under evaluation by the US Food and Drug Administration (FDA) and predicted that "inhaled insulin should meet regulatory requirements for approval."

NEEDLE-FREE INSULIN

Using the lung as an absorption pathway has particular appeal for patients who, despite improvements in injection devices, still wince at the discomfort and inconvenience of administering multiple daily insulin injections. Reluctance to take injected insulin sometimes leads to patient noncompliance and poorly controlled blood glucose levels.

The lungs provide a large surface area (100-140 m^2) for drug absorption, and inhaled insulin is absorbed more rapidly than regular insulin injected sub-

An alternative to insulin injections, inhaled insulin could emerge as a viable, noninvasive avenue for administering the hormone.