Stroke Rehabilitation In The United States

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Stroke rehabilitation currently is a very exciting area in which to be involved. There is much going on with regard to clinical research, and much more to come.

The American Heart Association estimates that the estimated cost of care and earnings lost from stroke in 2007 was $62.7 billion. Approximately two-thirds of this was attributed to direct medical costs, such as hospital stays, physicians, drugs, equipment and rehabilitation. However, surprisingly, about one-third of the costs was related to lost productivity due to mortality and morbidity.

The longstanding studies in Framingham, Massachusetts, sponsored by the National Heart, Lung, and Blood Institute of the National Institutes of Health reported that 50% to 70% of stroke survivors regained functional independence. However, 15% to 30% of stroke survivors remain permanently disabled, and about 20% of stroke survivors were institutionalized 3 months after their strokes.

The basis of stroke rehabilitation has become clearer over the last 10 years with the advent of functional MRI and other similar diagnostic tools. However, back in the early 1980′s, Paul Bachy-Rita hypothesized that recovery from stroke occurs because of two mechanisms. The first mechanism involves intact neurons sprouting and re-innervating muscular regions after some or all of their input is destroyed. The second involves the unmasking of neural pathways-neuroplasticity-in which neurons and synapses not normally used for certain aspects of function are called upon when the original system fails. This occurs only with much repetition of the activity. Researchers have demonstrated that recovery after stroke may occur months or years. This has changed the entire premise that recovery from stroke ceases after about 3 to 6 months. In fact, it may be a self-fulfilling prophesy to tell stroke survivors that recovery ceases after a given period of time. Giving some hope may allow the stroke survivor to gain some function over months or years, or at minimum allow the stroke survivor to maintain what function he has.

These functional MRI films demonstrate how neuroplasticity occurs with activity. The large white arrows delineate the area of the stroke. The red areas identify activated pathways that allow a limb to function despite the destruction of its cortical representation. These areas tend to be in the peri-lesional areas, the pre-motor cortex in the frontal lobe, and in the homologous areas of the contralateral cortex(Fig 1).

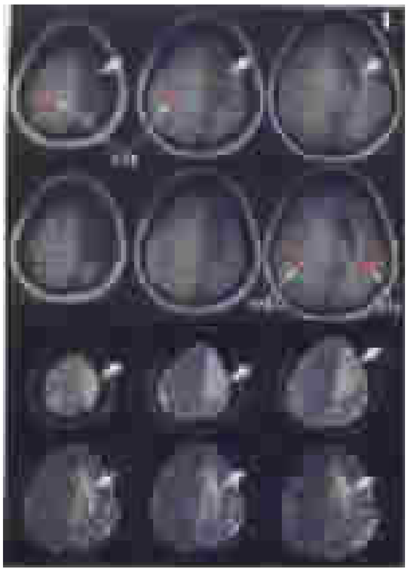

Fig 1

In this study by Liepert from Stroke in 2000, transcranial magnetic stimulation was used in 13 stroke survivors after constraint-induced movement therapy to measure cortical representations. Before treatment began, the affected hand muscle cortical representation appeared smaller than that of the unaffected side. After treatment, the affected hand muscle representation became larger. After a 6-month follow-up, the sizes of cortex representing the hand in both hemispheres became nearly identical. This demonstrates how the brain is able to reorganize itself to maximize function despite the presence of acquired damage.

This is how I envision the treatment protocol for patients who have had a stroke. Initially, when Emergency Medical Services arrive on the scene, they will administer some drug that will protect areas of the brain that are susceptible to further damage. Unfortunately, no neuroprotective agent has been demonstrated to be effective thus far. Once the patient reaches the Emergency Department, tPA or some other means of dissolving clots will be used. If there is any residual functional deficit, drugs can be used to stimulate the brain to function and reorganize itself. Along with these drugs, intensive rehabilitation will be needed to provide the intensive repetition that allows the brain to establish new pathways. Both drugs and intensive therapies should not be started for at least one week, since animal and human studies have shown detrimental results when neurostimulants and intensive therapy were started too early.

A number of different classes of medications have been studied in motor recovery after stroke. In this Cochrane meta-analysis, ten trials studied 287 patients were analyzed. The quality of the trials varied, but there was no evidence that amphetamine treatment reduced death or dependence. Patients with more serious strokes were allocated to amphetamine treatment, and may have accounted for more deaths at the end of follow up. Adverse effects such as increases in heart rate and systolic and diastolic blood pressure were noted. As a result, no definite conclusions about the effects of amphetamine treatment on recovery from stroke could be reached.

In 1998, Grade studied 21 subjects randomized to methylphenidate or placebo for 3 weeks. His analysis demonstrated improvements in depression as well as function despite no statistical improvements in motor function.

Amantadine is a dopaminergic agent that has been studied for use in improving mental status as well as walking. In this small study, statistically significant gains in components of gait were demonstrated in stroke survivors who received amantadine.

Levodopa also has been studied in conjunction with physical therapy by Scheidtmann in 2001. In this prospective, randomized, placebo-controlled, double-blind study of 47 subjects receiving levodopa or placebo for 3 weeks, clinically meaningful improvements measured by the Rivermead motor assessment were demonstrated after 3 and 6 weeks of treatment. Therefore, levodopa may be an appropriate medication to use in the subacute phase of stroke.

A number of medications also have been studied for use in conjunction with therapy for aphasia. In this meta-analysis, 10 trials were analyzed, but the quality of these trials could not be assessed. Only piracetam, a cyclic derivation of GABA, showed weak evidence of its ability to improve language function. However, the authors concluded that larger studies were needed to reach adequate statistical power.

Now, let's turn to one therapy technique that has clearly demonstrated efficacy in one large patient population. Steve Wolf from Emory University in Atlanta, Georgia, headed the first prospective, single-blinded, randomized, multisite clinical trial of constraint-induced movement therapy (CIMT), sponsored by the National Institutes of Health. In this study, 222 stroke survivors with predominantly ischemic stroke 3 to 9 months prior to the study were assigned to receive either CIMT or usual and customary care. CIMT consists of restraining the unaffected arm in a sling and mitt, while providing intensive occupational therapy to the affected arm 6 hours per day for 10 days over a 2-week period. The inclusion criteria, which are quite strict, included being able to move the affected arm 20 degrees in wrist extension and 10 degrees of finger extension. In fact, the inclusion criteria were so strict that the recruitment rate was significantly under 5%.

The outcome measures included the Wolf Motor Function Test (WMFT), that measures time and ability to perform certain pre-determined functions. The Motor Activity Log (MAL) is used outside the laboratory at home to measure of how well and how often 30 common daily activities were performed.

After the initial treatment period, patients were evaluated up to 12 months after treatment ended. In all cases, patients receiving CIMT demonstrated significant improvements in performance time, amount of use, and quality of movement when compared with the control group.

Intensive therapy of aphasia also may produce improvements in speech similar to that which CIMT produces for motor recovery. Pulvermuller compared 10 subjects receiving aphasia therapy at least 3 hours per day over 2 weeks with conventional therapy. He found significant improvements on several standard clinical tests, self-ratings, and blinded-observer ratings of communicative effectiveness when compared with stroke survivors who received conventional therapy for approximately 4 weeks.

Another technique for stroke recovery that has been studied in depth is body-weight-support treadmill training. Using this technique, patients are placed in a harness system that offloads a portion of their body weight. They are placed on a treadmill that allows them to practice ambulation under the supervision of one or more therapists.

This technique allows stroke survivors to reduce the cardiac load of exercises. In 2000, Danielsson studied a convenience sample of 9 hemiparetic subjects and 9 healthy subjects. The ventilatory oxygen uptake (VO_2) and heart rates of patients walking with 30% body weight support were significantly lower than that of subjects who ambulated with no body weight support.

Despite this cardiac advantage, it did not appear that body-weight-support treadmill training produced a significant statistical or clinical effect. In this meta-analysis, 15 trials including 622 subjects demonstrated no difference in measures of walking speed and independence.

Treatments with electrical stimulation have been used for a long time. In this intervention using neuromuscular electrical stimulation (NMES), muscles (in this case, the tibialis anterior) were passively activated to prevent foot drop and allow more functional gait.

More recent devices have been developed for specific functional purposes. Both of these devices are produced by Bioness, a company in the United States. On the left (Fig 2), the electrodes over five muscle groups pick up electrical signals and assist in the movement of the wrist and hand. On the right (Fig 3), a sensor detects the angle of the leg and stimulates the tibialis anterior at the appropriate time to allow ankle and toes clearance during swing phase.

Fig 2

Fig 3

This device, the Walk Aide, is produced by Innovative Neurotronics in the United States. It has a sensor that detects the angle of the leg and stimulates the tibialis anterior at the appropriate time to allow ankle and toes clearance during swing phase.

But what is the evidence for the use of functional electrical stimulation in stroke rehabilitation? Twenty-four randomized clinical trials were analyzed in this meta-analysis. There were many differences between randomized controlled trials including populations, electrical stimulation doses, and outcome measures. In majority of studies no significant improvements in function was found when electrical stimulation and therapy were compared to no treatment. As a result, the authors of this analysis reported insufficient robust data to support or refute the clinical use of electrostimulation for neuromuscular re-training.

In addition to neuromuscular and functional electrical stimulation, EMG biofeedback also may play a role in motor recovery from stroke. This is the NeuroMove, an EMG biofeedback device produced by Stroke Recovery Systems in the United States. It allows the user to set an electrical threshold that must be reached before the device stimulates the target muscle. As the user becomes more adept at using the device, the electrical threshold may be raised so that the user must work harder to stimulate the target muscle. EMG biofeedback also may contribute to neuroplasticity of the brain.

But what is the evidence for the use of EMG biofeedback in stroke rehabilitation? In this meta-analysis, 13 trials involving 269 subjects were studied. Subjects received either EMG biofeedback with standard therapy or standard therapy with or without a sham treatment. Once again, results were limited because trials were small or generally poorly designed. Functional outcome scales varied from study to study. As a result, the combination of all identified studies showed no significant treatment benefit.

Another area of intense research in motor recovery is robotics. Robots can provide therapy without direct human supervision while providing entertaining ways to keep the subject interested in the therapy. This device uses visual feedback to direct a subject to move his arm in certain ways to reach a target. If the patient has difficulty to reach the target, the robot can provide a certain amount of movement to "teach" the limb how to move.

This is a more sophisticated (and expensive) version of a robot with visual feedback. This is the Reo, produced by Motorika in the United States. It also can be used to train a subject in movement of shoulder and elbow of the affected arm. Its cost is about 60,000 USD.

This device, the Lokomat made in Germany, is a far more sophisticated robot that permits active, active assisted and passive ambulation for patients with neurological deficits. Its cost is about 250,000 USD. As with many of the other technologies I have discussed, there is no definitive evidence to support or refute their use for motor recovery after stroke.

Probably the most invasive approach to stroke rehabilitation is a cortical stimulation system used in conjunction with occupational therapy for the upper extremity. Functional MRI is used to identify an activated site for hand, usually in the penumbra of the stroke. An epidural electrode is placed over the site indicated by the functional MRI by craniotomy. A pulse generator, similar to a pacemaker, is implanted just below the clavicle. Once the patient recovers from the surgery, the cortical site is stimulated during therapy. The current is submaximal such that the patient does not feel the stimulation and the only movement of the hand is produced by the patient, not the electrical stimulation.

In this combined data of two earlier studies of cortical stimulation, subjects receiving cortical stimulation were observed to have more clinically meaningful gains in movement than that of the control subjects. Movement was measured by the Fugl-Meyer motor assessment scale.

Summary

I have attempted to present you with many of the ways that in the United States we are addressing the issue of motor deficits in stroke survivors. Many of these techniques show promise. However, there is much work to be done in order to determine which techniques may be the most effective for certain patients. It is also need to figure out the timing of many of these techniques in order to maximize their benefit. As this last slide shows, stroke survivors need to be "involved with their own rescue." Without their motivation and practice, stroke survivors will never reach their maximal functional capacity. With new techniques and technologies, rehabilitation professionals can provide stroke survivors with the means to intensify their therapies to facilitate functional recovery, reorganize the brain and return them to a fulfilling quality of life.

(整理：首都医科大学宣武医院康复医学科周景升、宋为群)