Emerging Strategies for Rehabilitation of the Stroke Patient

In the past few decades, new understanding about the plasticity of nervous system organization coupled with innovative techniques for physical therapy have provided new options for post-stroke rehabilitation.

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An 86-year-old woman with a history of a left MCA stroke comes into your office for follow up six months after the acute event. She has had a standard course of physical and occupational therapy in acute care as well as a home-based program following discharge. She is accompanied by her daughter who expresses disappointment in the patient’s level of recovery and hopes her mother can regain the ability to prepare meals for herself in the kitchen and possibly walk outside. On exam, the patient has continued right upper limb weakness and decreased coordination.

What new rehabilitation options are available to this patient and what factors would help you decide on a recommendation?

Stroke and Rehabilitation

Stroke is a leading cause of disability with over 30 million survivors worldwide, according to the World Health Organization. Lifetime economic costs related to stroke are estimated to be in excess of $230,000. Comprehensive rehabilitation, including range of motion, strength training, energy conservation, and use of adaptive equipment, has long been the mainstay of stroke rehabilitation. Traditional frameworks for stroke rehabilitation have focused on compensatory strategies (switching to writing with the left hand following right hemiparesis), strategies to facilitate synergistic patterns (Brunstrom Approach), and strategies to suppress synergistic patterns (Bobath Approach). However, there is little data to suggest the superiority of one approach over another in stroke rehabilitation. Over the past few years, novel strategies for stroke rehabilitation have emerged that take advantage of a better understanding of neural recovery as well as advances in computers and robotics. While many trials of these novel strategies have small sample sizes and poor controls, an expanding body of literature is proving their efficacy. The aim of this review is to give the practicing neurologist an overview of these emerging approaches to stroke rehabilitation so they can field questions like the one posed by the patient above.

Constraint-Induced Therapy

Prior to the 1980s, neuroscientists since Broca had viewed the structure of the central nervous system to be hardwired and fixed. Only recently have researchers uncovered the tremendous amount of nervous system reorganization that can occur in the wake of a neurological insult. Constraint-Induced Therapy (CI Therapy) is an outgrowth of our understanding of neural plasticity. It is thought that following a stroke, there is a positive feedback called “learned nonuse” that prevents an individual from using the hemiparetic limb. In this model, decreased movement of the affected limb leads to less cortical representation of the affected limb, which leads to even less movement. The original research done by Taub in 1993 showed that CI therapy could improve function following a plateau in improvement and that these gains were maintained two years after the
The Extremity Constraint Induced Therapy Evaluation (EXCITE) Trial proved the utility of this technique as a way to achieve long-term, functionally significant improvements in arm function three to nine months following stroke. This prospective, randomized, controlled trial involved 222 people at seven different clinical sites.

Constraint induced therapy typically involves immobilization of the non-affected limb in order to increase the use of the affected limb. While it is typically applied to the upper limb, it can be applied to the lower limb, as well (Fig. 1). Immobilization can be carried out using a mitt or a sling. CI therapy has also been used to treat patients with aphasia. In this model, non-verbal communication, such as gestures, are prohibited during therapy so the patient is forced to communicate through speech alone.

Despite the proven clinical effectiveness of CI therapy, there are downsides to this treatment. Patients are expected to restrain the unaffected extremity for a target of 90 percent of waking hours over a period or two to three weeks. Patients have reported that this is difficult to tolerate, and therapists have expressed concern about having enough clinical resources to provide CI therapy in a safe way. This may indeed limit the utility of CI therapy outside the laboratory environment. It is also important to note that participants in the EXCITE trial did not have significant cognitive deficits, were free from balance problems, and did not have excessive pain. Finally, there is some recent suggestion that high intensity CI-therapy may be harmful when applied in the days and weeks immediately after stroke.

Mirror Therapy (MT) and Graded Motor Imagery (GMI)

Mirror Therapy and Graded Motor Imagery are other approaches to stroke rehabilitation. Like CI-therapy, the goal is to reverse the “learned disuse” following stroke. In both MT and GMI, a mirror is placed in a sagittal plane. When the patient looks into the mirror and toward the affected limb, a reflection of the non-affected limb is seen (Fig. 2). This substitutes for the absent proprioceptive and abnormal sensory input of the affected limb. MT has been shown to be helpful in the recovery of function in upper and lower limb movement impairments in stroke patients. Cacchio demonstrated improvement in sensory/attention deficits and motor function in upper extremity hemiplegia in a randomized controlled study of MT. Both MT and GMI have been shown to produce changes within the primary sensory and motor cortices on fMRI.

MT has been most commonly used for stroke rehabilitation and phantom pain following amputation. GMI has been most commonly used in the treatment of chronic pain. The research on GMI has focused on its efficacy in CRPS and phantom pain. It has been demonstrated by RCT to be effective in the treatment of CRPS. Both MT and GMI appear to work by similar mechanisms stimulating mirror neurons in those areas of the brain that have been adversely affected by “learned disuse” or overactive protective responses due to neurological injury or pain. This stimulation can produce a positive plasticity re-establishing normal sensory and motor processing.

GMI has evolved from mirror therapy. It has been noted that the observation of what appears to be the affected limb in a mirror can increase the pain or produce a profound emotional effect and/or kinesthetic dissonance. Too rapid a progression of activities can be counter-productive. GMI uses a progressive series of brain exercises and activities to restore laterality (the ability to discriminate left from right).
right body parts), sensory awareness, limb recognition, visualization of movement, and controlled movement to restore pain-free function. This graded sequencing can prevent pain or other adverse responses produced by the shock of seeing what appears to be the affected limb in the mirror. Through this sequencing and the avoidance of adverse responses, the reinforcement of the painful or non-productive neural pathways can be prevented and pain-free, productive pathways reinforced and developed.

Robotics and Functional Electrical Stimulation

The application of electrical current to a nerve for the purpose of stimulating a muscle contraction in a paretic or plegic limb is referred to as functional electrical stimulation or FES. Robotic arm training devices are machines designed to facilitate repetitive movements in the upper limb and utilize interactive software to replicate functional movements and provide feedback to the patient.

A recent meta-analysis review article published in the Cochrane database showed that both robotic arm trainers (AT) and functional electrical stimulation (FES) devices improve motor control and power in stroke patients when compared to conventional therapy programs, even in patients with severely paretic upper limbs. However, neither of these modalities was shown to significantly improve a patient’s ability to perform activities of daily living (ADLs) when compared to traditional therapies. The improvement in motor control may be related to a reduction in tone, specifically co-contraction of agonist and antagonist muscles.

While the vast majority of the evidence supports the use of FES and AT earlier in the post-stroke rehabilitation course, studies also exist demonstrating benefit in the subacute and chronic period. Not surprisingly, outcomes for both AT and FES were poorer when the patient demonstrated neglect. Although there is evidence to support the use of AT and FES in patients with severe paresis, most studies report improved outcomes with patients who are able to demonstrate some volitional activation of the target muscles. Therefore, these modalities may not be appropriate for patients demonstrating neglect or apraxia or who are unable to demonstrate volitional activation of the muscles in the upper limb.

As many as 80 percent of individuals develop shoulder subluxation after a stroke, which can impair upper limb function. There is evidence to support that functional electrical stimulation or FES, when used in combination with a traditional thera-
Virtual Reality and Wii-Habilitation

Virtual reality is a technology that allows a user to interact with a computer-simulated environment. The extent to which a virtual reality system succeeds in delivering this environment to the patient is termed “immersion.” Some of the most immersive forms of virtual reality include a head-mounted display that encompasses the patient’s entire field of view. Less immersive forms of virtual reality include projecting images onto a screen (sometimes with an image of the patient, as well), or simply using a computer monitor. Various systems may also provide auditory, haptic, vestibular, and even olfactory stimulation. A systematic review of six studies evaluating immersive and non-immersive virtual reality rehabilitation has shown that immersive VR might be superior to no therapy, while the data regarding non-immersive VR was conflicting.

Given the high cost of VR systems, an exciting development in the world of virtual reality rehabilitation is the low cost Nintendo Wii (pronounced wee). In this system, a controller called the Wii Remote allows a patient to direct the activities of an onscreen player. The remote can also vibrate and make sounds to provide haptic and auditory feedback, respectively. In our experience, the Wii Sports software that is included with the system is well received by patients. This software includes games like tennis, golf, and bowling. These games can be played in a sitting or standing position with either the affected or unaffected limb. (Fig. 3) In our center, we have anecdotally found the system helpful to improve coordination, direction following, attention, balance, and standing tolerance. Unfortunately, the Wii was not designed for rehabilitation, and there is little evidence of its utility or transferability. Safety would also be a concern in a non-supervised outpatient setting. Unlike the more expensive virtual reality systems, it is not whole body contact and therefore less immersive. However, its low cost (the Wii retails for under $200 USD) and wide appeal certainly makes it an attractive adjunct to standard rehabilitation therapies.

Conclusion

Returning to the case presented initially, what might we recommend to the patient and her daughter? While CI-therapy has a robust evidence base, we would need to gauge the patient’s level of motivation. It would be important to educate the patient on the difficulty of having her good arm immobilized 90 percent of the day and be sure that her daughter could be around often enough to support her. It would also be important to evaluate her balance and cognitive status and make sure she has at least some volitional activity in her hemiparetic limb.

MT and GMI are less burdensome physically than CI and require equipment that can either be made or purchased for less than $100. Both techniques require persistence and diligence to be successful. Both techniques should be practiced for five to 10 minutes four to five times per day. If she is emotionally labile, is disoriented by the mirror, or...
has significant pain, it may be preferable to follow a GMI program. The assistance of the daughter would be helpful in monitoring and in evaluating her performance. In MT and GMI, ongoing follow-up would be needed to sequence the activities and exercises performed as progress is made.

If shoulder subluxation and pain were a significant part of the clinical picture for this patient, the use of robotic arm training and functional electrical stimulation could be helpful. As with constraint therapy, she would need to have some function in her affected limb and be free from significant neglect or poor insight into her deficits. Given the high incidence of cardiac pathology in this population, it would be important to query whether she has a pacemaker.

Finally, there is evidence to suggest that virtual reality may be helpful to this patient if this resource is available in the area. You may advise the patient to seek the most “immersive” system possible. Consideration of use of a Wii unit would be a fun option if the patient is open to the prospect, especially if the patient had participated in a sport such as golf or bowling before the stroke. The patient could start by playing games in a sitting position. However, given the lack of data regarding the safety of this option, it would be prudent to recommend a session of Wii supervised by a physical therapist to make sure that the patient can use the system safely.

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