Neuroplasticity in the Aged Brain

Demonstration of neuroplasticity in the human adult brain, including aged brains, has been the source of renewed hope, interest and funding in the field of rehabilitation of stroke and neurologic injury. Initial studies as far back as the 1960s and 1970s by Scheibel (Scheibel et al. 1976), Rosenzweig (Rosenzweig et al. 1962), Coleman (Coleman and Riesen 1968), and others demonstrated beneficial effects of environmental enrichment on the aged brain. Aged rats housed in small groups were compared to those housed with young pups and presented each day with novel “toys” to explore. Histologic analysis of dendritic arborization showed significantly greater dendritic branching and cortical thickness for aged rats exposed to enriched environments. Studies by Merzenich (Merzenich, Nelson, and Stryker 1984) and others showed electrophysiologic evidence of cortical remodeling following digit amputation in squirrel monkeys. Areas previously responsive to stimulation from the amputated digits became responsive to sensory stimulation of the remaining adjoining digits. Nudo (Nudo et al. 1996) and others have used a squirrel monkey model to study the effects of stroke lesions placed over the motor cortex responsible for hand function. Adjacent cortex previously producing face and shoulder movements when electrically stimulated began producing hand movements in response to hand motor re-training protocols. Nudo’s studies provide major support for the importance of motor training and motor learning as necessary and sufficient for the electrophysiologic changes observed.

Stroke is an age-related disorder, and recovery following stroke is a good example of neuroplasticity inherent in an aged brain. Functional magnetic resonance imaging (fMRI) and electrophysiologic studies in humans using transcranial magnetic stimulation (TMS) both provide strong evidence for neural plasticity in humans following stroke. Strokes affecting the motor cortex or sub-cortical white matter projections from the primary motor cortex are associated with increased fMRI activation of ipsi-lesional pre-motor cortex, and homologous contra-lesional primary motor cortex (Cramer et al. 1996). More severe strokes are associated with less ipsi-lesional pre-motor cortex and more prominent contra-lesional homologous motor cortex fMRI activation (Cramer et al. 2001). Ipsilateral pre-motor cortex activation may be beneficial, while contra-lesional motor cortex activation may be detrimental. Transcranial magnetic stimulation studies also support the ability of pre-motor cortex to effect movement in paretic muscles following stroke. This has been most convincingly described by Liepert et al. (Liepert et al. 1998) following a course of constraint induced therapy (CIT) focused on intensive training of the paretic hand following stroke.

Neuropharmacology, Molecular Neurobiology and Neurogenetics in Rehabilitation

There is increasing awareness that traditional neurorehabilitation techniques described below may be further enhanced by our understanding of the role of neurotransmitter systems on arousal, attention, motivation, cognition, behavior, and motor learning. Psycho-stimulant agents such as dextroamphetamine (Crisostomo et al. 1988), methylphenidate (Grade et al. 1998), amantadine (Barrett and Eslinger 2007) and modafinil have all been used to enhance arousal and attention following stroke and traumatic brain injury. They may also enhance motor learning and improve motor performance both in normal subjects and in patients with stroke or traumatic brain injury. Serotonergic agents such as the selective serotonin re-uptake inhibitors improve mood and motivation in depressed patients following stroke (Miyai and Reding 1998). Cholinesterase inhibitors and NMDA receptor blockers have shown benefit for cognitive impairment due to vascular dementia (Bowler 2004). Dopamine receptor blockers have a limited role in ameliorating psychotic behavior in patients with Alzheimer’s disease, vascular dementia, and delirium following stroke or traumatic brain injury (Dervaux and Levasseur 2008). Recent advances in molecular neurobiology suggest novel strategies which may limit initial neuronal injury, the neuro-inflammatory response to injury, or the apoptotic response produced by ischemic stroke, traumatic brain injury, or spinal cord injury. Key molecules or molecular pathways identified include: hypoxia inducible factor (HIF) (Ratan et al. 2007), tissue necrosis factor-alpha (TNF-α) (Jayaraman et al. 2005), Histone deacetylase (HDAC) inhibitors (Simm et al. 2007), and PPAR-gamma agonists (Lee and Reding 2007). These have all been identified as potential targets for neuropharmacologic intervention. Knowing how and when to either inhibit or promote these molecular targets promises to add significantly to our ability to promote neuronal responsiveness to traditional rehabilitation techniques. Appropriate modulation of molecular mechanisms underlying neuronal survival and neuroplasticity should aid recovery of motor, perceptual, cognitive, and behavioral impairments in the future.

Neuro-genetic advances have shown that Apolipoprotein E (ApoE) polymorphisms may identify patient populations with differential susceptibility to Alzheimer’s disease or differential recovery following traumatic brain injury (Abboud et al. 2008). Patients with one or more ApoE-2 allele are less likely to develop Alzheimer’s disease, and they show better functional recovery following traumatic brain injury compared to patients with one or more ApoE-4 allele. Brain-derived neurotrophic factor (BDNF) polymorphisms involving valine/valine and
methionine/methionine substitutions identify different functional recovery patterns following TBI and stroke (Siiroinen et al. 2007). The importance of brain-derived neurotrophic factor for neuronal survival and recovery is self-evident. Catechol-O-methyltransferase (COMT) polymorphisms involving valine and methionine substitutions are also relevant for recovery following brain injury (Bosia et al. 2007). The putative mechanism of action for different COMT polymorphisms involves their differential effect on mono-amine synthesis and indirectly their effect on enhancement of recovery. The challenge for clinicians will be to identify pharmacologic interventions that appropriately target and ameliorate the above-mentioned dysfunctional genetic polymorphisms. With time, there will undoubtedly be many more genetic variations identified that predispose to development of neurodegenerative disorders, and inhibit recovery from neuronal injury.

Traditional Neurologic Rehabilitation

Rehabilitation is an effort to bring back lost function. Geriatric rehabilitation cannot hope to restore the functions of youth, but attempts to optimize the individual's ability to function given the constraints of the aging process. The World Health Organization (WHO) has advocated that we consider different aspects of loss of function: 1) impaired function at the level of a body organ, such as brain, heart, muscle, bone, etc.; 2) impaired function at the level of the organism such as being able to feed, dress, groom, bathe, walk, etc.; and 3) impaired function at a social level, being able to fulfill our roles as spouse, friend, worker, citizen etc. This three level WHO classification of functional loss is often summarized by using the terms respectively: Impairment, Disability, Handicap (Barbotte et al. 2001).

Aging is associated with loss of function in each organ system. The WHO classification of function is useful in organizing our approach to geriatric rehabilitation. This WHO classification helps focus rehabilitation efforts on conceptually distinct aspects of the geriatric patient's function.

Priority is placed on optimizing organ system impairment. If there is cognitive impairment, what strategies can retard or improve cognitive function? At present, this would lead one to consider prescribing an acetyl-cholinesterase inhibitor, or N-methyl dopamine antagonist. If there is congestive heart failure, what strategies can optimize cardiovascular function? Reviewing the patient’s sodium intake, use of diuretic, beta blocker, and angiotensin converting enzyme inhibitor would be most important.

Once organ system impairments have been optimized, there may be need for additional strategies to ameliorate disability with self-care and mobility functions. Using the examples above, for the patient with cognitive impairment this might entail recommending use of a memory book, pill dispenser, or delivery of pre-cooked meals. For someone with CHF, prescribing a hospital bed with head elevation may help with orthopnea, moving bed and toilet facilities to the same level of the home, or using a bedside commode will help conserve energy.

Handicap issues are addressed by accessing services to help support the patient’s independence in their home and community. Examples would be use of home care or daycare programs while family members are at work. For patients without a family caregiver, arrangements could be made for daily calls by a volunteer to check on the patient’s well being and adherence to their medication regimen. Referral to other community services can provide transportation for health care appointments, or to attend rehabilitation or wellness programs.

Using the concepts of impairment, disability, and handicap, it is easy to categorize geriatric rehabilitation intervention strategies, and to some extent the skill set of the clinicians providing these services.

For addressing organ system impairments one would expect a physician with special expertise in the organ system affected to be most helpful. For ameliorating disability, a physiatrist (or other physician with special training in rehabilitation medicine), a rehabilitation nurse, occupational therapist, physical therapist, speech language pathologist, social worker, and psychologist are all likely to be able to provide useful treatment and advice. Handicap issues reflect dysfunction fulfilling accustomed social roles in the home or community and are usually addressed by a social worker or psychologist with referral for specific equipment or services as needed.

Rehabilitation care is evolving from a multi-disciplinary to a trans-disciplinary approach to patient management. The above discussion implies that each of the clinicians involved in geriatric rehabilitation has a special set of skills, that the skill set is sufficiently broad as to be inadequately mastered by any one clinician. This concept of a multi-disciplinary approach to rehabilitation is changing to a trans-disciplinary concept of care. A trans-disciplinary approach recognizes that there is considerable overlap in many of our rehabilitation disciplines, and that clinicians should be encouraged to cross traditional boundaries compatible with their experience and care settings. Common examples of overlap treatment areas are occupational therapy addressing ambulation and transfer techniques to and from the tub and toilet, or addressing dysphagia-related food and liquid consistency modifications and swallowing strategies to improve deglutition. Ambulation is traditionally considered to be a physical therapy task and dysphagia a speech-language pathologist’s treatment area. The trans-disciplinary approach encourages clinicians to focus on the patient’s needs, and not on the clinician’s job description.

Rehabilitation Strategies to Improve Organ System Impairments

This book is entitled Clinical Neurology of Aging. Its focus is on neurologic changes associated with aging. Many neurologic disorders, however, may be secondary to age-related changes in other organ systems, to altered metabolism or adverse effects of prescribed medications. Before focusing on specific neurologic impairments it is prudent to assess the patient’s general medical condition, other organ system co-morbidities, and medication list for factors that may adversely affect neurologic function. Chapter 52 is specifically devoted to a review of neurologic side-effects of medications.

Cardiovascular changes are most obviously manifested as stroke. Chronic obstructive pulmonary disease may be associated with treatment-related steroid or xanthine oxidase inhibitor cognitive-behavioral side effects. More advanced pulmonary disease can lead to hypoxic encephalopathy or carbon dioxide narcosis. Age-related changes in gastrointestinal function may lead to B12, folate, and other vitamin and nutritional deficiencies giving rise to brain, peripheral nerve, and neuro-muscular wasting disorders. Details of age-related changes in brain-gut neuropeptide interactions involving leptin, ghrelin, somatostatin, cholecystokinin are yet to be elucidated. Renal-electrolyte abnormalities affecting neural function most commonly seen in the elderly are pre-renal azotemia and hypernatremia due to inadequate hydration. Hypernatremia may be due to diuretic use, inappropriate anti-diuretic hormone secretion, or to age-related renal dysfunction with resultant salt-wasting nephropathy. Age-related endocrine disorders with neural consequences are diabetes mellitus, thyroid, and parathyroid dysfunction. Many age-related myelodysplastic and neoplastic hematologic disorders predispose to stroke by causing either hyper or hypo-coagulable states with thrombocytosis, thrombocytopenia, or polycythemia.
"minimizing training interference performing competing tasks during the same treatment session." There are six prospective randomized studies that do not show superiority of any one particular physical therapy approach over the others: traditional, PNF, NDT, or MLT. These studies involve small numbers of patients and have been scored by observers who were not blinded to the type of treatment given. Most therapists utilize various techniques from each approach based upon the patient's response, which may differ significantly depending upon the interval since stroke onset.

Selected neuropharmacologic agents have been studied for their ability to improve neurologic impairments following stroke and traumatic brain injury. L-dopa and dopamine agonists have been used to help improve expressive speech and language deficits. The initial studies, often with single subjects using ABA trial design, were encouraging. Subsequent studies with larger sample sizes have not shown these agents to have significant effects on speech fluency measures (Gupta et al. 1995). L-dopa and dopamine agonists have also been studied for their ability to help improve visual-spatial hemi neglect following unilateral parietal lobe stroke or traumatic brain injury (Fleet et al. 1987). Initial reports were encouraging but not supported by subsequent larger studies.

There are limited data suggesting that use of dextroamphetamine or methylphenidate may enhance motor recovery following stroke. The first controlled, double-blind clinical study was performed in 1988 and showed a significant benefit of 10 mg dextroamphetamine given orally one hour prior to subsequent physical and occupational therapy focused on paretic upper and lower limb strengthening exercises (Crisostomo et al. 1988). Assessments of strength were performed the next day and seemed to imply a durable enhancement of motor scores. There were, however, only four dextroamphetamine subjects and four placebo controls. A subsequent double-blind, randomized control study of 21 stroke rehabilitation patients using daily doses of 10 mg dextroamphetamine at 9AM each morning prior to daily PT and OT therapy sessions for two weeks showed no benefit on motor strength scores, Barthel Activity Of Daily Living Scores, or Beck Depression Scores (Ratan et al. 2007). Lack of benefit with daily dosing suggested that patients may show a tachyphylactic response to daily dosing of dextroamphetamine, which has a seven hour half-life. Patients in the initial study who showed a beneficial dextroamphetamine effect were only 7 days post stroke, and in the subsequent study were 21 days post stroke at study entry. Most of the patients in the initial study had only motor paresis, while 70% of the subjects in the subsequent study had more extensive stroke-related impairments with hemiparesis, hemihypertrophy, and hemianopic visual deficits. Several subsequent dextroamphetamine studies have been performed, some showing benefit, others not. Methylphenidate, which has only a two hour half-life, was used on a daily basis in one study and showed improvement in motor scores compared to placebo (Martinsson, Wahlgren, and Hardemark 2003). It is possible that the short half-life of methylphenidate may allow sufficient time for withdrawal; that it may not show a tachyphylaxis response with daily dosing. Discrepant outcomes have focused debate on the need for more information concerning the effects of time post stroke, the severity of motor deficit, and dosing regimen on pharmacologic response. At present there is not sufficient evidence to advocate use of either dextroamphetamine or methylphenidate as a pharmacologic agent to enhance motor recovery following stroke.

More specialized interventions have been studied following acute neurologic disorders such as stroke, traumatic brain injury, spinal cord injury, and to a lesser extent in chronic progressive disorders such as Parkinson's disease and multiple sclerosis. Such treatment techniques include: constraint-induced therapy (CIT) (Grotta, Noser, and Ro 2004), Functional Tone Management (FTM) (Saebo Inc) upper limb orthotic devices, functional electrical stimulation (FES) (Ring and Rosenthal 2004), transcranial direct current (TCD) stimulation, robotic therapy (Stein et al. 2006), and partial body weight supported treadmill training (PBWSTT) (Kosak and Reding 2000). Applicability of these techniques to geriatric patients with deficits from stroke, Parkinson's disease, or traumatic brain injury has been documented.

The simplest approach for enhancing upper limb function of selected patients with arm and hand paresis following stroke is to force them to use their paretic hand by constraining the good hand in a sling or covering it with a boxing glove this is the technique of constraint-induced therapy (CIT). Use of a constraint on the unaffected hand is what gives this technique its name (Grotta, Noser, and Ro 2004). In order for patients to be appropriate for this training strategy, they must have at least 10 degrees of voluntary finger flexion/extension and 20 degrees of voluntary wrist extension. Given this degree of voluntary motor control it is possible to begin modeling the patient's movements so that they can practice progressively more complex hand functions.

The protocol usually requires one-to-one patient-therapist interaction in massed practice sessions at least six hours a day five days per week for two weeks. Modifications of the protocol allow small group sessions with several patients working with one another, but always with constant occupational therapist supervision and facilitation. Selection of tasks must be challenging but not beyond the patient's capabilities, and modified as they show improvement in hand function. The constraint condition is used while the patient is awake for most of the day, even when not in therapy sessions for this two-week period. The patient may be allowed to remove the constraint condition for feeding, toileting, and bathing if necessary. CIT works best for patients with paresis plus superimposed learned non-use of the paretic hand. The concept is that because of the severity of their initial weakness, the patients gave up making the effort to use their plegic hand for daily self-care and other functional tasks. Severe weakness plus hemisensory or visual-spatial neglect are thought to further promote development of learned non-use. Most studies have validated CIT as a means of improving the patient's use of the paretic limb in daily activities. Outcome measures assessing muscle strength changes have shown less significant improvement. There is general consensus, however, that CIT is beneficial when used as described above.

Use of a Functional Tone Management orthotic device is a simple approach for improving grasp and release for selected patients with hemiparetic upper limbs following stroke (Saebo Inc) (see Figure 1). The orthotic is meant to be a training device allowing patients to practice grasp and release hand functions, initially with large diameter, but light, puffy-ball type objects. As range of finger flexion-extension improves, the size and weight of objects manipulated can be altered to increase task difficulty. The natural recovery of hand function following stroke is for patients to have some ability to voluntarily flex the fingers. There may, however, be no ability to extend the fingers, making it difficult to initiate grasp release. The FTM device is a simple exoskeleton fitting over the dorsum of the forearm, wrist, and hand. Finger cots resembling thimbles are placed over each finger and thumb, and are attached by springs to five struts mounted on the dorsally situated orthotic. Adjustments are made on the spring tension for each digit to allow the patient's voluntary finger flexor movements to just barely overcome the finger extensor tone provided by the spring-loaded finger extension force. The value of this device is provided by simple demonstration of hand function with use of the device versus without its use. Repetitive practice over time allows eventual discontinuation of the FTM orthotic as voluntary grasp and release improve. This device can be used to improve voluntary finger flexion-extension to
allow the patient to qualify for initiation of constraint-induced therapy as described above.

Functional electrical stimulation (FES) of the affected shoulder, arm, and hand has been shown to improve spasticity, shoulder subluxation, and motor strength scores in selected patients with hemiparesis post stroke. FES as a rehabilitation treatment tool has been available since the 1950s. Early FES used bulky equipment requiring a 115 volt current source, metal electrodes, and painful levels of stimulation current. Today we have compact portable multi-channel programmable battery-powered stimulators that deliver stimulation currents which are easily tolerated by patients. At least two FES systems are commercially available, each with a different electrode configuration design for stimulating appropriate muscle groups in the upper versus the lower limb (Ring and Rosenthal 2004; Stein et al. 2006) (see Figure 2). The devices are easily adjustable by an appropriately trained occupational or physical therapist to optimize electrode placement, stimulation parameters, and comfort. The patient and caregiver are trained to apply the device themselves, and may purchase or lease it for daily use in their homes. Some of the devices can be manually triggered to provide stimulation of forearm finger flexors, thumb flexor, and forearm finger-extensor muscle groups to allow functional grasp and release. Some of these FES systems are designed to sense weak and ineffective surface EMG activity from voluntary muscle activation and use these patient-initiated EMG signals to trigger larger, more functional muscle contractions by the FES stimulator. The gains seen in motor scores, spasticity reduction, and secondary joint contractures, while statistically significant, have not been sufficiently robust to translate into improvements in self-care scores. These devices, like the FTM orthotic, may be used to improve voluntary finger flexion-extension to allow the patient to qualify for initiation of constraint-induced therapy as described above.

FES has also been shown to help improve foot-drop and functional gait while being worn on the hemiparetic leg by selected patients following stroke. As for the upper limb, the FES systems are fitted by the patient’s therapist, adjusted to optimize quality of gait, then purchased or leased by patients for daily use in their homes (see Figure 3). The devices are battery powered, compact, and safe. Electrical stimulation parameters and timing are actuated by either an accelerometer in the device or foot-plate sensor placed in the sole of the patient’s shoe. Surface-mounted electrodes under the FES device are held in place over the peroneal nerve by elastic straps. Use of FES for foot-drop following stroke may improve quality of gait and help strengthen foot dorsiflexors. This is in contrast to use of an ankle-foot orthosis, which if not used appropriately, may inhibit motor recovery.

Transcranial direct current (TCD) stimulation is a new electrical stimulation technique that is gaining interest as more data supporting its mechanism of action and potential clinical effects becomes available. When direct current is passed through the brain, the threshold potential of cortical neurons is lowered under the anodal (+) electrode and it is raised under the cathodal (-) electrode. Clinical trials using
TCDC have been limited and initiated only in the past several years. It is too soon to speak about efficacy, but this new technique is receiving growing attention as a modulatory tool for facilitating recovery of speech and language, motor recovery, and for treatment of hemispatial visual neglect (Fregni 2005). Each of these neurologic impairments is thought to be modulated by competitive input to remaining ipsilesional cortex from homologous region of the contra-lesional hemisphere. There is now sufficient evidence to show that inhibition of recovery by the unaffected hemisphere does indeed occur. This evidence is based on functional magnetic resonance data and transcranial magnetic coil stimulation and inhibition studies. Given this information, it is reasonable to use TCDC to enhance neuronal function in affected ipsilesional cortex, and inhibit detrimental competing input from the homologous contralesional cortex. The neuroscience data supporting the potential value of TCDC as a new stroke and TBI treatment tool have generated considerable optimism and warrant thorough study.

There are now several robotic systems that are commercially available for use in upper limb motor recovery following stroke (Volpe, Krebs, and Hogan 2003; REO Therapy, Motorika USA Inc.). They allow a robotic device to move the paretic arm or hand to follow visual cues on a video monitor (see Figure 4). They use different computer game protocols to present the patient with a movement task that requires the patient to move the cursor to specific targets. Initially the robot may be programmed to wait variable periods of time for the patient to respond. If there is no response, the robot begins the desired movement, carrying the patient’s arm through the motion. As the patient’s strength, speed and accuracy improve, the robot is programmed to provide less assistance. The programs also challenge patients by increasing target speed of presentation, and by providing either steady or random resistance to movement. In a 45 minute treatment session, the upper limb robot may be able to present the patient with more than a thousand goal-directed movements. The variability of video games and the responsiveness of the robot to patient performance keep the patient challenged and engaged in the task. Controlled studies have compared robotic upper extremity training with traditional occupational therapy in patients who are more than six months post stroke and who have reached a plateau in their upper limb motor scores. Such studies show an approximate 20% improvement in favor of robotic therapy compared to traditional occupational therapy. This improvement in motor score has not however translated into significant improvement in upper limb self-care scores. Use of robotic systems for enhancement of motor function is in its infancy. It is hoped that with more advanced systems, patients will be able to practice more functional tasks with robotic assistance provided across multiple joints.

Partial body weight supported treadmill training (PBWSTT) is now an established approach to help recover ambulation following stroke or incomplete spinal cord injury (Kosak and Reding 2000) (see Figure 5). Selected patients with significant weakness who are difficult for a therapist to mobilize using simpler techniques such as temporary bracing, quadruped cane, and hemi-bar are most likely to benefit. The body is fully supported by a parachute type harness that allows the patient to be supported over a moving treadmill. The patient’s paretic or plegic leg is guided through the gait cycle from single stance, toe push, swing phase, and heel-strike by their therapist who is seated alongside the treadmill. The speed of the treadmill is steadily advanced as the patient’s gait quality improves. Several of the difficulties of this technique are that the patient must be able to cooperate, and support 70% or more of their body weight. There must be at least this degree of patient participation to show a treatment effect. Due to gait dyspraxia and difficulties with pelvic weight shifting during the gait cycle, an additional therapist may be needed to model movement of the nonparetic leg, and another therapist may be needed to assist with pelvic shift during the gait cycle. The time spent placing the harness on the patient, and the need for additional therapists or therapist aides to assist with movement represent relative impediments to this form of assisted gait training. There are now two commercially available robotic gait trainers that provide all assistance needed for both leg movements and pelvic tilt. Their ease of use and need for less manpower are, however, offset by their initial cost and maintenance expense.

**Figure 4** This robotic upper limb trainer may initially assist limb movement to reach for a target on the video screen. As the patient improves, the device is programmed to provide less assistance, and advance target speed to keep the video tasks challenging.

**Figure 5** Partial body weight-supported treadmill training device allows the patient to practice walking while safely protected from falling by a body harness. The therapists can help control paretic leg movement and pelvic tilt during the gait cycle to allow the patient to practice “normal” walking.
Rehabilitation Strategies to Improve Disability with Self-care and Mobility

After attempts have been made to minimize the patient's neurologic impairments, using the strategies rehearsed above, one is often left with the need to help the patient adapt to the deficits that remain. Rehabilitation tools which are primarily adaptive in nature can be classified as compensatory techniques or adaptive devices. Techniques are taught that make living with residual neurologic impairments easier and safer. Devices are recommended that will help optimize ease and safety of specific self-care and mobility tasks.

Compensatory Techniques

The focus of this chapter is on geriatric neurologic rehabilitation. Many other considerations and options are appropriate for geriatric patients with orthopedic, rheumatologic, and cardio-pulmonary disabilities. Though quite important, they will not be addressed here.

Occupational therapists are specially trained to teach techniques for helping geriatric patients remain in the community as independently and safely as possible. To do this they must assess the impact of the patient's residual neurologic impairments: cognitive, perceptual, motor praxis, motor paresis, motor coordination, sensory deficits, balance, and gait. The most common cause of neurologic disability in the USA is stroke, followed by Alzheimer's disease, benign essential tremor, Parkinson's disease, and other neurodegenerative disorders.

Stroke victims with residual cognitive, perceptual, motor, sensory, and balance impairments serve as a common and extreme example of the difficulties involved in optimizing a patient's functional independence.

Patients with memory deficits can be taught mnemonic techniques based on visual, spatial, or linguistic strategies to enhance list learning, or recall of activity sequences needed to complete a motor task.

Visual search techniques can be taught to help patients with hemianopia or unilateral visual neglect to properly scan their environment to finish the food on their plate, or find obstacles in their path before they attempt to transfer from bed to wheelchair, or before they stand to walk.

Urinary urge incontinence and constipation related to neurologic impairment can be ameliorated by teaching timed-prompted voiding techniques, and by appropriate use of dietary fiber modifications, stool softeners, and suppositories. These techniques are often rehearsed and reinforced by the rehabilitation nurse. Timed prompted voiding assumes that the patient has impaired awareness of bladder filling and impaired ability to voluntarily inhibit micturition. Adequate fluid intake is assured by encouraging 1.5 liters of fluid per day, consumed prior to 6PM. Timing voiding to half an hour after each meal and at two hour intervals between meals while awake acknowledges the need to void related to fluid intake at mealtime, the patient's unawareness of bladder filling, and their inability to inhibit automatic micturition. Geriatric patients in general and particularly following stroke are relatively immobile. Immobility is a risk factor for constipation and fecal impaction. Use of a 35 gram fiber diet, a stool softener such as docosate nightly, and bisacodyl suppository every other day if no bowel movement are reasonable approaches to prevent impactions, and allow the patient to time evacuation of stool. Placing the bisacodyl suppository may itself initiate the anal-colic reflex directly. There is also a direct stimulatory effect of bisacodyl on the smooth muscle of the rectal ampulla, further stimulating evacuation. The bowel and bladder management of geriatric patients is very important for quality of life.

Residual hemiparesis may require the patient to learn to live their life one-handed. The simplest tasks such as grooming, bathing, feeding, dressing, and toileting can seem impossible for a hemiplegic patient. There are, however, specific techniques which can be taught that will help the patient accomplishing each of these tasks whether they involve use of the dominant or non-dominant hand. Managing trunk support and safety as one lifts under-clothing and pants may require learning how to dress while supine or while performing a hemiplegic sit-to-stand or stand-pivot transfer maneuver. This is accomplished by learning to stand, balance, and pivot using the unaffected leg. The hemiplegic dressing sequence starts with dressing of the paretic arm first. Different techniques are then taught for pullover versus front-buttoning clothing. Other tasks such as cooking, laundering, and home-making may need to be taught, depending upon their appropriateness for the patient's residual impairments and home environment.

The physical and/or occupational therapist may need to teach the hemiplegic patient how to prepare themselves for rising from the sit-to-stand position. Prior to stroke, this function would have been performed unconsciously. Following stroke, the patient may need to mentally rehearse the sequence to position the paretic leg parallel to the non-paretic leg, and "bring the nose over the toes." This assures proper positioning of the body's center of gravity in order to allow for safe sit-to-stand transfer. Hemiparetic gait sequencing must be taught to patients with need for cane and brace who are not able to safely swing the paretic leg from toe-push to heel strike in one fluid motion. This involves advancing the cane (held in the non-paretic hand), then advancing the paretic leg to the level of the cane, then finally advancing the non-paretic leg to the level of the cane. (See Figure 6) This three-part sequence, "cane, paretic leg, good leg" seems simple to learn, but may take the stroke victim a week or two of rehearsal before the movement sequence becomes relatively automatic. The hemi-paretic stair-climbing sequence is another technique which improves function and safety. Hemiparetic patients are taught to go "up with the good leg, and down with the bad." Using the unimpaired leg to raise the body's weight to the level of the next step is mechanically sound. Safely positioning the paretic leg in full extension on the descending stair provides maximum support of the patient's full weight as the non-paretic leg is brought to the same level. Some therapists are reluctant

Figure 6 Traditional hemiplegic gait training using a quadruped cane, and ankle-foot-orthosis with therapist assistance.
to use the term "bad leg" but "with the good and down with the bad" is too easily remembered to be discarded.

Most dysphagia treatment strategies use diet modifications or compensatory swallowing techniques to improve deglutition. Diet modifications can provide an appropriate food consistency (puree, ground, chopped, or mechanical soft diet) to allow the patient with impaired motor control of lips and tongue to manage food appropriately for their level of buccal-labial-oral motor control. Lip function is important for maintaining lip seal with liquids; tongue function is required for moving the food bolus in the mouth allowing for adequate mastication. Once the food is properly prepared for swallowing, the tongue must move the food bolus to the entrance to the oral pharynx. Once past the anterior faecal pillars, the food or liquid bolus normally triggers the swallow reflex. Liquids are particularly difficult to contain during the oral phase of deglutition, and may prematurely spill into the oral pharynx. The most common pharyngeal abnormality seen following stroke is delay of the swallow reflex, with delayed elevation of the larynx and inadequate protection of the airway. Elevation of the larynx plus posterior excursion of the tongue and evagination of the epiglottis are essential for closure of the laryngeal airway. Providing the patient with thickened liquids of either nectar or honey consistency is an appropriate strategy to help improve control of the liquid bolus in the mouth, and slow down the flow of liquid once it enters the pharynx, thereby lessening the risk of aspiration.

Multiple other compensatory dysphagia treatment strategies are also available. Their use is indicated if they can be shown to be helpful in improving functional deglutition by objective means such as videofluoroscopic modified barium swallow (VMBS) (Finestone et al. 2002) test or fiberoptic endoscopic evaluation of swallowing with sensory stimulation (FEESST) (Rees 2006) study. Commonly used compensatory swallowing techniques include: head turn, chin-tuck, Mendelson maneuver, swallow- cough sequence, and supra-glottic swallow. The value of each is dependent upon objective demonstration in a particular patient; that use of the technique obviates laryngeal penetration or aspiration of the test material, or that it helps clear any spillage past the epiglottis into the laryngeal vestibule.

**Functional Assist Devices**

The most commonly used mobility assist devices are cane, walker, brace, and wheelchair. Canes are useful for stabilization of gait and for pelvic weight shifting during the gait cycle. They are useful for patients with hemiparesis, orthopedic back or lower limb joint limitations, or arthritic pain. Proper use of a cane requires that in double-stance phase of gait, the elbow of the hand holding the cane is slightly flexed 7 to 10 degrees. This allows for elbow extension, which can provide additional support without need to disturb shoulder-girdle and upper trunk balance. The cane chosen should provide the smallest base of support needed to meet the patient's needs. The progression is as follows: standard cane, bent-handle cane, tripod cane, quadraped cane. Tripod and quadraped canes can be either narrow based or wide based.

Walkers also help with balance and weight shift, but are more cumbersome and require two hands for manipulation. They are considered when use of a cane is not sufficient. Rolling walkers are easier to use but less supportive than platform walkers. Walkers are available that have additional features such as a seat if the patient becomes fatigued, and carrying basket to add functionality.

Use of an ankle brace may be appropriate for patients with an unstable ankle, foot-drop during the swing phase of gait, or knee buckling during the single-stance phase of gait. A flexible ankle-foot orthosis (AFO) or hinged-ankle AFO will help provide medial-lateral stability of a paretic ankle as well as dorsiflexion assistance during the swing-phase of gait. Fitting patients with a more supportive rigid-ankle AFO can be used to inhibit knee buckling during the single stance phase of gait over the paretic leg. A prefabricated AFO intended for temporary use may be prescribed if likely to be needed only for a month or two. A custom molded AFO is appropriate if longer use is anticipated or if adequate fit and comfort cannot be obtained using a prefabricated brace. (See Figure 7)

Need for a wheelchair or motorized scooter implies more significant disability. If a patient is to spend more than an hour or two a day in a wheelchair or motorized scooter, it is important that they be tailored to the patient's size and needs. Wheelchair evaluations are commonly done by the occupational or physical therapist. There are over 100 options that need to be considered when ordering a wheelchair: seat height, seat width, chair weight, seat-cushion, back height, need for lateral support, headrest, legrest specifications, brace extension, etc. Motorized chairs and scooters are usually reserved for patients unable to self-propel a manual chair, or who need to be independent over longer distances at work or in the community. There is a cardio-pulmonary advantage associated with encouraging the patient to propel their own wheelchair. The main contraindications for use of a motorized chair are impaired cognition, judgment, or safety awareness due to hemi-spinal visual-field deficits. Patients may need both a motorized chair for the home and a light-weight transport wheelchair for use moving from home to car to the community.

The most common home safety devices prescribed are associated with improving safety in the bathroom while assisting with toileting and bathing. A raised toilet seat and armrests make rising from sit-to-stand easier and safer. Grab bars affixed to the wall can also help transitioning on and off the toilet or to the tub or shower. Tub bench and Showerwall® allow the patient to bathe while seated using the hand-held shower-head. Ramps, doorway modifications, motorized chair lifts for managing stairs, etc., are all appropriate for selected individuals (see Figure 8). An occupational therapy review with the patient and family or a visit by the therapist to the home will help assure that the patient's home has been optimized for their safety. A home visit by the therapist may reveal fall hazards such as poorly organized furniture, throw rugs, etc., that impede ambulation or wheelchair use.

The occupational therapist and patient have access to catalogs full of devices that can help with every aspect of self care. Some of these devices may help the patient with bilateral rheumatologic hand deformities or hemiplegic patients with use of only one hand. These ADL device catalogs feature items that one without disability might

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Figure 7 Alternative ankle-foot-orthoses used for treating foot-drop due to either central or peripheral motor control disorders. From left to right, flexible AFO, solid ankle AFO, hinged ankle AFO.
not imagine. Examples include toothpaste dispensers, soap holders, button hooks, one-handed potato peelers, etc.

Rehabilitation Strategies to Minimize Handicap

Handicap within the World Health Organization classification signifies disability fulfilling the patient’s accustomed interpersonal functions. These roles are multi-faceted such as within the family as spouse or parent, outside the family as a friend, member of a club or other organization, and at work if not retired. These social roles are usually managed ad-hoc by the individuals involved. While the patient still has adequate mental capacity it is important to encourage them to consider and sign a living will, health care proxy, and power of attorney which will be needed if should they become cognitively impaired in the future. These documents assure that their wishes and their best interests are pursued by who they designate. These arrangements are usually made by the patient and their family with legal advice if there is likelihood of anyone contesting these documents in the future. If there is question of the patient’s capacity to make appropriate judgments, then formal neuropsychological assessment may be necessary. If there is impaired mental capacity and no designated health care proxy, or power of attorney, then referred to adult-protection services or other legal assistance will be required to initiate a competency hearing, with the final decision as to the patient’s mental competence decided by a judge. Chapter 12 presents a more complete discussion of mental capacity, mental competence, and legal aspects of assisting geriatric patients with health care decisions. The theme that pervades these interactions is to balance the patient’s need for self-determination with their need for a safe care environment.

Initial clinical social worker assistance may be in the form of arranging for home care through local visiting nurse services, or for further out-patient rehabilitation services. An illness sufficiently severe as to require hospitalization usually meets criteria for coverage of home-care services for several weeks by the Center for Medicare Services.

For a major illness such as stroke, this may include home visits by a nurse, several hours of home health aide assistance each week, speech-language pathologist visits for treatment of aphasia or dysphagia, and occupational therapist and physical therapist visits as appropriate.

The clinical social worker is expected to be aware of local community-based programs for the patient to provide socialization, a mid-day meal, and exercise-wellness programs to maintain optimum general health and well-being. The social worker can help arrange for handicapped transportation and parking services to facilitate participation in community activities.

Day care programs can be quite beneficial for the patient, and a welcome respite for the caregiver. The social worker is also expected to be aware of local caregiver support groups.

The clinical social worker is also a valuable resource for patient and family considering the need for more supervision and assistance, particularly appropriate for disorganized patients with progressive degenerative neurologic disorders. The social worker can discuss options such as hiring a part-time or live-in home health aide, moving of the patient to an independent living facility, to an assisted living facility, or to a nursing home. Documentation of the patient’s level-of-care needs can be formally evaluated by nursing, physical therapy, or occupational therapy assessment of self-care and mobility function. Such geriatric evaluation scales are discussed more fully in Chapter 13.

Many geriatric rehabilitation programs incorporate an assessment by a recreational therapist. The recreational therapist helps patients optimize their ability to resume accustomed recreational activities. Such activities are important for maintaining quality of life threatened by progressive impairments due to the many geriatric neurologic disorders covered in this book. Recreational activities may require modification to accommodate cognitive, perceptual, motor, or coordination deficits. Adaptive devices may be available to help overcome residual neurologic impairment: card holders, large print books, books on CD or iPod format, etc. The recreational therapist is often able to provide craft activities that extend the work of the physical therapist, occupational therapist, and speech therapist outside of regular therapy hours. Careful thought must be given to assure that such craft activities
are compatible with the patient's interests and within the limits of their motor skills to complete. Recreational activities can also be designed to reframe linguistic, cognitive, perceptual, and coordination skills.

Optimal Geriatric Neurologic Rehabilitation Outcomes: A Team Approach

This book discusses common problems encountered in geriatric neurology. Each reader will have a different perspective and interest depending upon their background as geriatrician, neurologist, internist, family physician, or other clinician. The above discussion of geriatric neurologic rehabilitation strategies for optimizing impairment, disability, and handicap is intended to stress the breadth of clinical skills currently available to optimize the patient's independence in their home and community.

It would be ideal but unrealistic to hope that each patient has access to a coordinated geriatric neurologic rehabilitation program in their area. Inability to create this ideal need not deter one from modeling the care delivery system as closely as possible to this goal within their practice setting.

The geriatric clinician usually has access to a nurse who can help with self-care and mobility assessments. Problems identified can be referred to a physical therapist or occupational therapist colleague in the community. Bracing needs can sometimes be met using prefabricated braces, but hinged ankle or custom molded braces will require referral to an orthotist. The geriatric nurse specialist is an appropriate person to discuss bowel and bladder care issues. General nutritional screening for body mass index, lipid panel, fasting glucose, renal-electrolyte balance, and serum pre-albumin might prompt referral for more formal nutritional evaluation and treatment. Aphasia and dysphagia would prompt referral to a collaborating speech-language pathologist.

Appropriate referrals can be made by the geriatric nurse or collaborating clinical social worker for problems with any of the above impairments, disabilities, or handicaps. These may require specific rehabilitation interventions, access to ongoing community meal delivery programs, wellness programs, home care programs, or day programs.

The geriatric neurologic rehabilitation clinic model need not take place within the same building. What is important is the communication, mutual respect, and follow-up that is practiced among the multiple clinicians. With time and rehearsal, the several individual clinicians comprising this community-based team will learn to function as a unit. Each of the members will be encouraged to suggest alternative treatment strategies and know that their suggestions are being carefully considered.

The most difficult component of the geriatric neurologic rehabilitation clinic to reproduce in a community setting is the scheduling of face-to-face meetings of team members rehearsing the patient's current treatment plan, progress, and goals. Conference calls and HIPAA-compatible Internet communication may, however, help overcome this obstacle.

References


REO Therapy, Motorika USA Inc., 523 Fellowship Rd, Suite 228, Mount Laurel, NJ 08054.


