Stroke Rehabilitation

David C. Good, MD, FAAN; Kerstin Bettermann, MD, PhD; Raymond K. Reichwein, MD

ABSTRACT

Despite improvements in prevention and acute management, stroke remains a common condition and a major cause of permanent disability. For patients who have had a stroke, an effective rehabilitation program is critical to maximize functional recovery and quality of life. Rehabilitation can occur in a number of different physical settings and is often coordinated by a comprehensive interdisciplinary team of professionals. Rehabilitation includes retraining to regain loss of function and teaching compensatory strategies when that is not possible. A number of interesting training approaches have been developed in recent years to supplement more traditional rehabilitation programs. A variety of adaptive devices is available to improve mobility and performance of self-cares, and these devices should be prescribed for appropriate patients. Physicians caring for patients during stroke rehabilitation must be aware of potential medical complications, as well as a number of special problems that may complicate recovery, including dysphagia, urinary incontinence, shoulder pain, spasticity, falls, and poststroke depression. Involvement of the patient and caregivers in the rehabilitation process is essential. It is important to train and educate these individuals in the physical aspects of poststroke care, the expectations for recovery, and secondary stroke prevention. Issues related to community reintegration, including driving and vocational aspects, should be addressed in appropriate patients. Stroke rehabilitation is an important part of the ''stroke continuum of care,'' which includes prevention, acute management, rehabilitation, and secondary prevention.

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INTRODUCTION

Stroke is a common condition and comprises over half of neurologic admissions to community hospitals. Stroke also receives considerable attention in neurology residency training programs, which primarily focus on the acute management of stroke. The toll of stroke is substantial; it is the third leading cause of death in the United States, behind heart disease and cancer. With increased survival poststroke and the aging of the population, the number of stroke survivors with disabilities is increasing. Stroke is acknowledged as the leading cause of significant disability in adults. The cost to society is enormous, with the estimated cost of care and earnings lost because of stroke in 2010 estimated at $73.7 billion.[1]

Most neurologists are well versed in the acute management of stroke and are familiar with important issues related to primary and secondary prevention. However, fewer neurologists are familiar with the rehabilitative aspects of stroke. This is unfortunate, because neurologists are in a unique position to participate in the complete stroke continuum of care, including acute admission, rehabilitation, follow-up care, and secondary prevention. At the very least, knowledge of stroke rehabilitation allows a neurologist to answer questions from the patient and family regarding secondary complications from stroke, long-range prognosis, and issues related to the long-term psychosocial sequelae of stroke. This article provides a current

Address correspondence to Dr David C. Good, Penn State Hershey Medical Center, Department of Neurology, 500 University Drive, PO Box 850, Hershey, PA 17033, *dgood@hmc.psu.edu*.

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KEY POINTS

- The goal of stroke rehabilitation is to ensure that each person reaches the maximum physical, functional, and psychosocial recovery possible within the limits of his or her impairment.
- Most recovery of specific deficits (motor, sensory, language) occurs during the first 3 to 6 months after stroke.

summary of the practical aspects of stroke rehabilitation, although newer concepts and techniques are also discussed.

The goal of stroke rehabilitation is to ensure that each person reaches the maximum physical, functional, and psychosocial recovery possible within the limits of his or her impairment. In theory, rehabilitation facilitates a degree of improvement greater than what would occur spontaneously. Ideally, stroke rehabilitation should facilitate relearning of skills that were possible before the stroke, but in some cases the focus of rehabilitation must be adaptation and compensation for deficits. This often means training both the patient and family to compensate for deficits that are irreversible.

Regardless of the strategies employed in stroke rehabilitation, the focus should be to maximize performance of activities of daily living; speech, cognitive, and mobility skills; and independence in the home and community.

NATURAL HISTORY AND PREDICTING RECOVERY AFTER STROKE

Most recovery of specific deficits (motor, sensory, language) occurs during the first 3 to 6 months after stroke.[2,3] There are exceptions, however, and documented improvements can occur many years after stroke in a cooperative patient with an intensive rehabilitation program.[4] Recovery of functional abilities can generally be predicted soon after stroke. Severity of disability status at 1 month poststroke is generally a reliable proxy for final outcome.[5] Some simple predictions are possible regarding motor recovery. If there is no voluntary movement in the upper extremity at 15 days or no measureable grip at 1 month, the prognosis for recovery of useful arm function is poor. If the patient can move his or her hip within a week, ambulation is usually possible, but often with the use of an assistive device or an ankle orthosis. Motor recovery almost always occurs initially in the proximal muscles of the upper and lower extremity and often occurs in a specific sequence, sometimes called the Brunnstrom stages of motor recovery (**Table 8-1**). Between 70% and 88% of patients with ischemic stroke have some degree of motor dysfunction[6]; however, long-term survivors have a good prognosis for motor recovery. In the Framingham Heart Study, 52% of individuals who survived at least 6 months had no residual weakness. Aphasia occurs in approximately 23% of patients following stroke.[7,8] Again, much recovery occurs within 3 to 6 months after onset. Some rough generalizations can be made. By 6 months poststroke only 12% of patients have continued aphasia. Degree of

TABLE 8-1 Brunnstrom Stages of Motor Recovery

Stage	Degree of Recovery
Stage 1	Flaccid paralysis
Stage 2	Movements in synergy pattern, emergence of spasticity
Stage 3	Voluntary synergy movements, producing movement across joints, increased spasticity
Stage 4	Voluntary movements outside of synergy patterns, decreasing spasticity
Stage 5	Developing control of individual or isolated movements
Stage 6	Return to near-normal motor control

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recovery correlates with the initial severity of the aphasia,[9] although functional communication may recover after 6 months in some cases of severe aphasia. Recovery from sensory perceptual and cognitive deficits generally follows the same pattern as motor and language difficulties. Neglect is present in as many as one-third of patients with acute stroke but resolves in most by 12 weeks.[7] When neglect persists, it can become a limiting factor to functional recovery.

Perhaps more important than recovery from any specific deficit is the ability to recover self-care activities and mobility. Many scales have been devised to evaluate activities of daily living (ADLs), including the Functional Independence Measure (FIM), which is commonly used in stroke rehabilitation in the United States. The FIM is a revised and expanded version of an earlier scale, the Barthel Index (BI). The BI is easy to score. A score over 95 (a perfect score is 100) correlates strongly with ability to function independently and return home. A score over 60 correlates with ambulation and care with assistance and is generally the cut-off point at which a patient with stroke can function at home with reasonable assistance of a spouse or caregiver. Improvement in BI score generally follows the same pattern as specific neurologic deficits (**Figure 8-1**).[10] Most recovery occurs by 6 months, and individuals who initially have poor functional abilities generally show less recovery. A study by Reding and Potes[11] provided insight into the interaction of specific deficits and functional recovery. Patients were divided into three groups: motor deficit only (M); motor plus sensory deficits (MS); and combined motor, sensory, and visual deficits (MSV). Using a life table analysis, 65% of the M and MS cohorts eventually became independent in ADLs, but less than 10% of the MSV group did. Nevertheless, a BI score of over 60 was achieved by most subjects in all groups, although at different time intervals (**Figure 8-2**). Other outcome measures used for stroke rehabilitation include measures of ambulation (eg, the ability to walk unassisted for 150 feet, the time required to walk 10 meters). The importance of other outcome measures, such as returning home or returning to work, is self-evident, and these outcomes are easily measured.

EFFECTIVENESS OF STROKE REHABILITATION

There is a general consensus that comprehensive rehabilitation programs are effective for retraining motor skills, preventing complications, and teaching adaptive techniques. Ideally, stroke rehabilitation should begin within the first 24 hours of stroke, and, if possible, occur on a stroke unit. Stroke units not only provide specialized medical care but also provide early intensive rehabilitation. A number of studies, mostly from the United Kingdom and Europe, have reported superior stroke outcomes for

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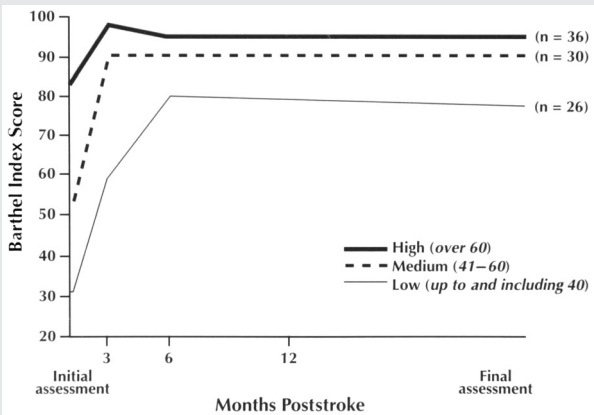


FIGURE 8-1 Recovery of ability to perform activities of daily living following stroke. The Barthel Index is a multifaceted assessment scale with a maximum score of 100. Note that patients with higher initial scores have better final outcomes than those with lower initial scores. Patients with lower initial scores (greater disability) improve more slowly.

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KEY POINTS

- Evidence demonstrates that comprehensive intensive rehabilitation may be superior to less-intense programs. Nonetheless, there is considerable pressure to provide rehabilitation in less-costly settings.
- Neuroimaging studies (such as fMRI) and neurophysiologic tests (such as transcranial magnetic stimulation) have demonstrated changes in cortical motor networks in response to training programs.

patients treated in comprehensive multidisciplinary stroke units compared to general medical wards.[12] These improved outcomes may be due at least in part to the intensive coordinated rehabilitation that patients receive in these units.[13] In the United States, stroke units are less well developed than in other Western countries. Acute hospital stays for stroke are often as short as possible and do not include intensive rehabilitation. The principal reason for this is reimbursement. Once medically stable, patients who are able to actively participate in therapy 3 hours a day and have a reasonable expectation of resuming community living are often transferred to rehabilitation units or hospitals. Length of stay for patients with stroke in these settings depends on the severity of neurologic deficit and comorbid medical conditions but averages about 2 weeks. In general, evidence demonstrates that comprehensive intensive rehabilitation may be superior to less-intense programs.[14,15] Nonetheless, there is considerable pressure to provide rehabilitation in less-costly settings, and patients unable to tolerate intensive programs are usually placed in ''subacute'' rehabilitation programs, often in skilled nursing facilities. For patients who are eventually discharged home, home health rehabilitation services and outpatient programs are usually recommended. It is important to consider the needs of individual patients when determining the location for rehabilitation services, however; third-party payers often heavily influence where rehabilitation is provided.[16]

About 25% to 30% of patients with acute stroke are candidates for comprehensive inpatient rehabilitation. This is usually coordinated by an interdisciplinary team that includes individuals with training in a variety of disciplines. Of course, not every patient requires the services of all of these individuals, but services that are required should be carefully coordinated. The patient and his or her family or caregiver are critical components of the team and should be involved in goal setting. Goals should be realistic and include both short- and long-term aims. They should be reevaluated on a regular basis and adjusted as needed. Training of the family or caregivers is often an important aspect of comprehensive rehabilitation.

Whether rehabilitation is truly ''restorative,'' in the sense that permanent improvement of neurologic impairment occurs, has long been debated. Randomized studies are difficult because of the complex interaction of variables that contribute to stroke outcome, including the magnitude of the neurologic deficit, concurrent medical illnesses, and psychosocial factors. Neuroimaging studies (such as fMRI) and neurophysiologic tests (such as transcranial magnetic stimulation [TMS]) have demonstrated changes in cortical motor networks in response to training programs.[17,18] These changes are somewhat correlated with outcomes, suggesting that intensive training, at least for motor deficits, might permanently

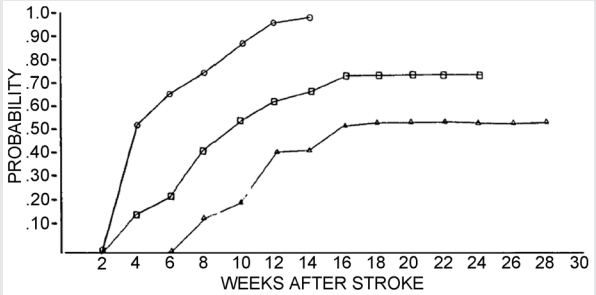


FIGURE 8-2 Life table analysis of the probability of reaching Barthel Index score of greater than or equal to 60. This is the level at which most patients can live at home with the assistance of a caregiver. *Circle*, patients with motor deficit only (n = 27); *Square*, patients with motor deficit plus somatic sensory deficit (n = 32); *Triangle*, patients with motor deficit plus somatic sensory deficit plus homonymous visual deficit (n = 32).

Reprinted with permission from Reding MJ, Potes E. Rehabilitation outcome following initial unilateral hemispheric stroke: life table analysis approach. Stroke 1988;19(11):1354–1358.

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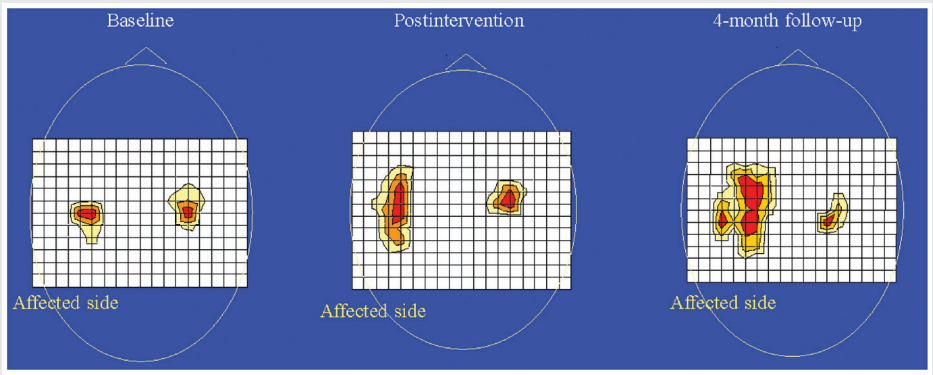


FIGURE 8-3 Longitudinal changes in a two-dimensional motor map obtained by using transcranial magnetic stimulation over the motor cortex of each hemisphere in a patient receiving constraint-induced movement therapy (CIMT) following stroke. The grid size is 1 cm, and motor responses at each scalp position are coded by intensity (relative to the maximal response). Note expansion of the motor map over the affected hemisphere associated with CIMT, which persists at 4 months.

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reorganize cerebral function. However, it is difficult to draw firm conclusions in this regard. The fact that intensive training programs (eg, constraint-induced movement therapy [CIMT]) are associated with changes in fMRI and TMS and apparently promote long-term recovery suggests that actual reorganization is occurring (**Figure 8-3**).

Teaching adaptive or compensatory techniques is also an important goal for rehabilitation, even if a permanent restoration of neurologic function is not possible. Training the patient and family in activities such as safe transfers, assisted ambulation, proper feeding, compensation for speech and language dysfunction, and provision of appropriate adaptive equipment are important goals of rehabilitation. The importance of these activities, as well as the importance of educating the patient and family about stroke outcome expectations and secondary prevention, should not be minimized.

MOTOR TRAINING APPROACHES

Both physical and occupational therapists are involved in motor training programs to enhance recovery. A number of methods and theories of therapy have evolved over the years, but no clear evidence exists that any of the older therapy programs is superior to any other. The most recent approaches have stressed the practice of motor tasks in the context of functional skills.[19,20] "Task-specific training" often means that new skills must be taught and motor activities must be performed in different ways than prior to the stroke. Evidence also suggests that more intense therapy enhances recovery. An example is CIMT (**Figure 8-4**).

KEY POINT

- No clear evidence exists that any of the older therapy programs is superior to any other. The most recent approaches have stressed the practice of motor tasks in the context of functional skills. Evidence also suggests that more intense therapy enhances recovery.

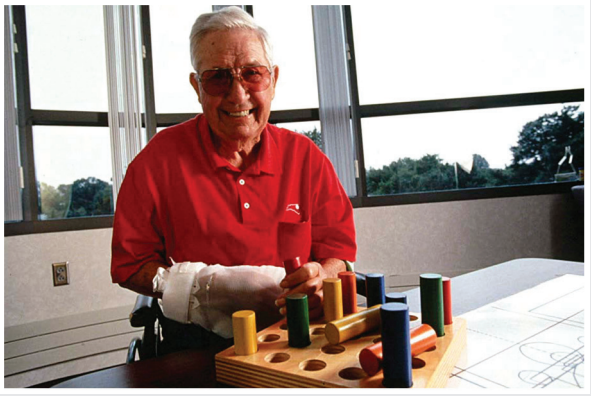


FIGURE 8-4 Patient with left hemiparesis receiving constraint-induced movement therapy. Note the mitt on his right hand to prevent the hand's involvement in this task.

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FIGURE 8-5 Patients undergoing robot-assisted training following stroke. The paretic left upper extremity is attached to a movable manipulandum. The patient is presented with a task on the computer screen and asked to move the cursor to successfully accomplish the task. The robot may provide assistance if desired.

Figure courtesy of Hermano Igo Krebs, PhD, Massachusetts Institute of Technology, Cambridge, Massachusetts.

In this technique, the unaffected hand is ''constrained,'' usually using a mitt. This forces the subject to use the stroke-affected hand in intensive functionally related tasks. In a randomized controlled trial, Wolf and colleagues demonstrated that daily intensive CIMT training was superior to ''usual care'' in a group of subjects 3 to 9 months after stroke.[21] Follow-up at 1 year continued to show modest improvement in motor function in the CIMT group. As used in this trial, CIMT training is very labor intensive and not practical for routine therapy. Another approach that uses intense repetitive training to facilitate recovery is the use of robotic devices (**Figure 8-5**). Many studies have demonstrated modest improvement in subjects who trained intensively with robotic devices for the upper extremity,[22] but a recent randomized controlled trial published by Lo and colleagues failed to demonstrate that intensive robot therapy was superior to intensive conventional physical therapy.[23] However, both techniques were superior to usual care, suggesting that intensity of training may be the most important factor in inducing recovery. A large meta-analysis[24] also suggested that intense therapy is associated with motor recovery. Another commonly used technique to enhance motor recovery is functional electrical stimulation (**Figure 8-6**). Evidence shows that this is effective in some patients.[25,26] A number of new experimental treatments have been proposed and were summarized recently.[20,27] These include bilateral arm training, electrical or magnetic



FIGURE 8-6 Functional electrical stimulation to facilitate ankle dorsiflexion.

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brain stimulation, sensory stimulation, and others. At present, none have achieved routine acceptance.

Patients most likely to improve with a motor training program for the upper extremity are those with some residual function. Good evidence indicates that the degree of damage to the corticospinal tract predicts final outcome.[28,29] Patients with a plegic upper extremity are unlikely to respond to any currently available motor training program.

An important goal for patients with stroke is ambulation (**Case 8-1**). Training can begin when the patient has demonstrated good sitting balance. For patients who are severely affected, training often begins in the parallel bars and then progresses to "overground" ambulation with assistance. The patient is encouraged to

KEY POINT

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Case 8-1

A 63-year-old woman was in generally good health except for hypertension. She developed a right basal ganglion intracerebral hematoma that also involved the internal capsule. Initially she had severe left hemiplegia but minimal sensory loss and neglect. After medical stabilization and control of her blood pressure, she was transferred to the rehabilitation hospital 1 week after the stroke. At that time she had no voluntary movement of the left upper extremity and was beginning to develop slightly increased tone in the flexor muscles of the elbow and wrist. In the lower extremity she had developed antigravity strength at the hip (3/5), 1-2/5 flexion and extension at the knee, and 2/5 plantar flexion, but no dorsiflexion, inversion, or eversion of the foot. Sitting balance at bedside required only occasional cues. She was fitted with a lightweight wheelchair with a seat sufficiently low to allow her to propel the chair using her right arm and right leg. Her left shoulder was supported in a wheelchair trough to prevent any traction or injury. The patient eventually became quite mobile on the ward and was able to propel herself to therapy and to the dining room. Initially, the patient was taught to stand in the parallel bars. Over the next week, she was gradually able to advance her left leg in the parallel bars, although she had no dorsiflexion and demonstrated significant hyperextension of the left knee during the terminal stance phase of gait. She was able to transfer to and from the wheelchair using a stand pivot transfer with minimal assistance from the therapist.

After 3 weeks of inpatient rehabilitation she was discharged to live with her daughter. The daughter and her family were available to provide 24-hour supervision. Rehabilitation continued on an outpatient basis. Over the next 2 months, the patient progressed to a hemi-walker (walker cane) and then to a wide-base quad cane. She was able to advance her leg independently but gradually developed increased plantar flexion tone, which exacerbated the hyperextension of her left knee during the terminal stance phase of gait. Active dorsiflexion or eversion of the foot never returned, but she developed excessive nonvoluntary inversion of the foot during the swing phase of gait. In consultation with an orthotist, a custom-made ankle-foot orthosis (AFO) was recommended. Specifically, a plastic solid AFO was ordered because she had no dorsiflexion. Additional support was provided to prevent foot/ankle inversion. The patient's ambulation improved, and she demonstrated better heel strike and less knee hyperextension. She did have continued mild circumduction. Eventually she was able to advance to a narrow-base quad cane and attained household ambulation and short-distance community ambulation. She continued to require a wheelchair for long-distance community activities. Her left arm, which developed increasing spasticity in a flexion pattern, never functionally recovered.

Comment. This patient demonstrates a fairly typical progression of mobility following a stroke with major initial motor deficit. The focus initially should be on balance, transfers, and supported ambulation, gradually advancing to a cane with a progressively smaller base of support and less assistance from caregivers and therapists. The AFO in this case resulted in less plantar flexion, less inversion, better heel strike, and less hyperextension (recurvatum) of the knee. Patients with severe initial paresis may never recover long-distance community mobility but can be quite independent in the home and for short-distance community mobility.

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FIGURE 8-7 Three commonly used assistive devices for ambulation after hemiparesis including (from left to right) a hemi-walker (walker cane), standard J-neck cane, and quad cane.

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place as much weight as possible on the paretic leg, and an optimal biomechanical and neuromotor gait pattern should be pursued but is not always possible. As the patient improves, a hemi-walker or wide-base quad cane may be used, progressing to a narrow-base quad cane or straight cane if possible (**Figure 8-7**). Eventually, walking over uneven ground, negotiating stairs, and higher-level gait activities are practiced. A popular technique is partial body-weight support with or without treadmill training. In this technique, the patient's weight is partially supported in a harness to allow a relatively normal gait pattern (**Figure 8-8**, **Video Segments 15** through **18**). A large multicenter controlled trial in North America is currently underway to test the efficacy of this technique.[30] For more information, see the article "Emerging Therapies in Neurorehabilitation."



FIGURE 8-8 Patient with a stroke in the left anterior cerebral artery distribution with weakness in right leg undergoing gait training using a treadmill with partial body-weight support.

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Many stroke patients benefit from an orthosis (brace), most commonly an ankle-foot orthosis (AFO) (**Figure 8-9**). An AFO may improve ambulation in several ways, including improving ankle

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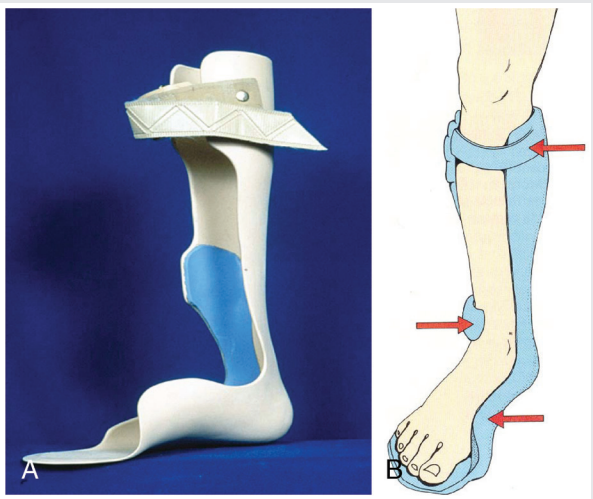


FIGURE 8-9 *A*, an example of a custom-made ankle-foot orthosis using a biomechanical ''three point'' force system to prevent ankle inversion in spastic hemiparesis. Blue material in the device protects against skin breakdown. *B*, arrows demonstrate points of force. The device also prevents excessive plantar flexion.

KEY POINT

- Many stroke patients benefit from an orthosis. An ankle-foot orthosis must be carefully designed to provide an optimal ambulatory advantage and to prevent pressure sores.

dorsiflexion, preventing excessive plantar flexion, providing medial lateral ankle stability, and improving the biomechanics of gait by changing force moments at the knee. Custom-made orthoses constructed by a trained orthotist are preferable, as orthoses must be carefully designed to provide an optimal ambulatory advantage and to prevent pressure sores. The need for an orthosis should be continuously evaluated because many patients do not need an orthosis long term. If the device does not provide a definite biomechanical advantage, the patient will usually abandon it. Close cooperation between a knowledgeable physician, physical therapist, and orthotist is important.

The use of pharmacologic interventions to enhance motor recovery has been a long-standing controversy, and further research is needed in this area. Early encouraging trials using amphetamine and methylphenidate have not been consistently replicated. For more details, see the article ''Emerging Therapies in Neurorehabilitation.''

ACTIVITIES OF DAILY LIVING

As previously mentioned, one of the most important rehabilitation goals after stroke is to resume as much independence as possible in performing ADLs. Independence in dressing, feeding,



FIGURE 8-10 Adapted eating utensils including built-up handles on spoon and fork, a rocker knife for one-handed cutting, a plate with raised edge, and a special surface to prevent the plate from sliding on the table.

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KEY POINT

- Family members or caregivers should be taught to assist when independence in activities of daily living is not possible.

bathing, and toileting adds immensely to a person's sense of self-worth and also decreases the burden on families and caregivers. Occupational therapists are skilled at teaching patients to relearn skills of daily living or to compensate when necessary. Family members or caregivers should be taught to assist when independence in ADLs is not possible. Many types of adaptive devices can be used to make the patient more functional and independent, including devices for feeding (**Figure 8-10**), dressing (**Figure 8-11**), hygiene, reading, and writing. A commode or a bathtub bench can also be very helpful (**Figure 8-12**). The home may need to be adapted by building ramps, moving furniture, changing door handles, installing grab bars, or widening doorways.

WHEELCHAIRS

Many patients with stroke need a wheelchair for mobility shortly after the stroke, and even those who recover household walking abilities may need a

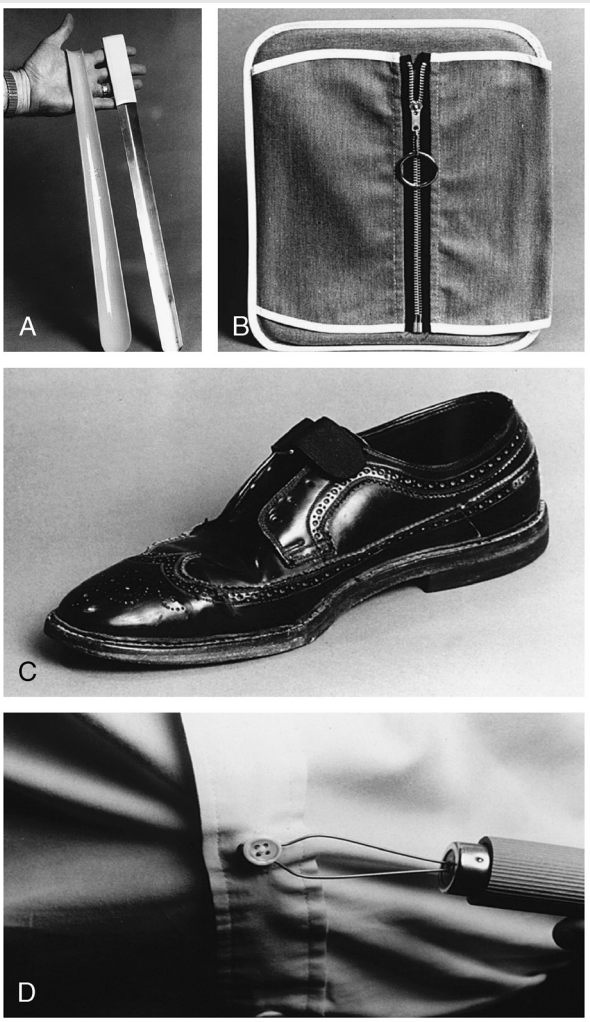


FIGURE 8-11 Adaptive devices to assist with dressing. *A*, long-handled shoe horns, *B*, ''ring'' zipper, *C*, Velcro shoe closure, and *D*, button hook.

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FIGURE 8-12 Two examples of equipment for home use. *A*, bathtub bench (which could also be used as a commode). Note several bathtub adaptations including several types of grab bars and a handheld shower nozzle. *B*, light-weight commode constructed with plastic tubing.

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KEY POINT

■ For a person with severe hemiplegia, the wheelchair seat should be 1½ or 2 inches lower than the standard wheelchair so the subject can propel the chair using the strong leg and arm.

wheelchair for long-distance community activities. Some patients may require a wheelchair for an extended period of time, even for home-based activities. Hundreds of different types and models of wheelchairs are available, but most patients with stroke can use a standard lightweight wheelchair (**Figure 8-13**). It is imperative that the wheelchair is appropriate for the patient. Important features include the seat width and depth and height of the back. Proper seating is necessary to ensure even weight distribution and avoid pressure ulcers. For a person with severe hemiplegia, the seat should be 1½ or 2 inches lower than the standard wheelchair so that the subject can propel the chair using the strong leg and arm. Detachable arm rests may be useful to facilitate transfers, and a proper foot rest with a detachable foot plate is also helpful. Other special devices may include brake extenders (to allow the individual to lock one of the brakes using the unaffected hand) and arm troughs to support the

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FIGURE 8-13 A wheelchair with standard foam cushion and commonly prescribed features, including swing-away leg rests, wheel grips to facilitate propulsion, and pneumatic tires.

paretic arm. Power wheelchairs are not generally necessary for patients with stroke but may occasionally be necessary in patients with limited recovery (**Figure 8-14**). They must be carefully prescribed, as the patient will be seated in the chair for an extended period of time, and the chair must permit maximum functionality. Motorized "scooters" are occasionally useful but are most appropriate for patients who can ambulate short distances at home but not in the community. The patient must be able to transfer to the scooter, have adequate cognition to safely operate the device, and be carefully trained in its use.

SPEECH AND LANGUAGE DISORDERS

The two major categories of speech and language disorders are the aphasias and dysarthrias. Most neurologists are quite familiar with aphasia, which is



FIGURE 8-14 Nonambulatory patient with right hemiparesis who uses a power wheelchair. Note arm trough for support of paretic arm.

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defined as an acquired impairment of verbal language behavior at the linguistic level. Several studies have suggested that intense treatment (at least 2 hours a day for 4 days per week) is more effective than a similar number of sessions spread out over a longer period.[3,31] Pharmacotherapy (bromocriptine, amphetamine, antidepressants, and donepezil) has been tried for aphasia, but no conclusive evidence exists that these drugs are effective.

Dysarthria is usually a synonym for ''slurred speech.'' Although it is often most severe with brainstem strokes, it can also be prominent in strokes of either hemisphere. In very severe dysarthria, alternative or augmentative communication devices can be considered. For more information on the impact of these disorders and their treatment, see the article ''Treatment of Language, Motor Speech Impairments, and Dysphagia.''

NEGLECT

Neglect is a general term that refers to asymmetric inattention to stimuli (visual or sensory) or motor function on the side of the body opposite the stroke. Although neglect most commonly occurs with nondominant hemisphere lesions, patients with dominant hemisphere stroke may also demonstrate neglect. The term spatial neglect refers to difficulty attending to one side of space. This is often accompanied by visual or sensory neglect and can be quite disabling. Patients may have difficulty caring for the affected side of the body, including dressing, cleaning, grooming, and feeding. Common scenarios include the patient with stroke who neglects the food on the left side of her plate, the person who misses words on the left side of the page (despite full visual fields), or the man who neglects to shave the left side of his face. See **Video Segments 1** through **7** for an example of a patient with severe left neglect following a right middle cerebral artery infarct. A number of simple tests for hemispatial neglect can be used, including asking the patient to cross out all of the lines on a page, to draw a clock, or to copy a figure. The line bisection test, in which the patient is asked to draw a mark exactly in the center of a line, is often used. Treatment of neglect is often complicated by lack of insight into the limitation. A number of treatments have been attempted, but none are uniformly successful.[7,32] Therapists often try visual and verbal cues to remind the patient to attend to the affected side, visual scanning, or somatosensory awareness training. A novel intervention for hemispatial neglect is the use of a prism, which shifts objects in the left visual field toward the right. Other attempted treatments include eye patching, virtual reality environments to facilitate attention to the neglected side, and vestibular stimulation. A number of pharmacologic treatments have also been tried, including amphetamines and amantadine, but none is consistently effective.

MEDICAL COMPLICATIONS DURING STROKE REHABILITATION

Patients who have had a stroke often have atherosclerotic risk factors including hypertension, diabetes, and heart disease, all of which can become medical issues on the rehabilitation unit. The involvement of an internal medicine specialist ensures that complicated medical issues are properly addressed.

A small percentage of patients can have recurrent stroke, and a few develop a seizure disorder as a consequence of the stroke. Neurologic consultation is certainly indicated in these situations. A number of general medical problems can occur in the poststroke period, including urinary tract infection (the most common infection during stroke rehabilitation), pneumonia (often associated

KEY POINTS

- Several studies have suggested that intense treatment is more effective than a similar number of sessions spread out over a longer period.
- Patients who have had a stroke often have hypertension, diabetes, and heart disease, all of which can become medical issues on the rehabilitation unit.

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KEY POINTS

- Probably the most feared medical complication during stroke rehabilitation is pulmonary embolism. All patients undergoing stroke rehabilitation who have significant limitation of gait should have prophylactic treatment for deep venous thrombosis.
- Half of patients with aspiration have no symptoms at all (''silent aspirators'').
- The most common cause of incontinence appears to be detrusor hyperreflexia with a coordinated sphincter, but a surprising number of patients have normal detrusor function and are incontinent simply because they cannot communicate the need to void.

with aspiration), and pressure ulcers. Many of these problems can be prevented. For example, early removal of a Foley catheter decreases the risk of urinary tract infections, upright posture and supervision during feeding can help prevent aspiration, and proper positioning in the bed and wheelchair can prevent pressure ulcers. When these problems occur despite good preventive care, they must be treated promptly. Probably the most feared medical complication during stroke rehabilitation is pulmonary embolism. Few medical situations are more frightening than being called to the therapy gym to see a patient who has become acutely short of breath accompanied by oxygen desaturation. The incidence of pulmonary embolism in patients undergoing rehabilitation for stroke has been estimated to be between 1% and 3%. At times the clinical presentation can be atypical, including chest or back pain exacerbated by change in position. Sudden unexpected death on the rehabilitation unit is often due to pulmonary embolism. All patients undergoing stroke rehabilitation should have prophylactic treatment (subcutaneous unfractionated heparin or low-molecular-weight heparin) for deep vein thrombosis.[7,33] For more information, see the article ''Management of Medical Complication.''

SPECIAL PROBLEMS FOLLOWING STROKE

Patients with stroke commonly have a number of other problems that need to be addressed during rehabilitation (**Case 8-2**). Some of these are discussed in other articles in this issue of CONTINUUM; however, because these conditions are so commonly associated with stroke rehabilitation, they are discussed briefly here.

Dysphagia involves disruption of normal swallowing mechanisms and affects normal eating. Aspiration is one consequence of dysphagia and should be suspected in patients with stroke who cough or choke when swallowing, develop a wet or ''gurgly'' voice, have an impaired cough associated with absence of gag reflex, or have recurrent pneumonia. Bedside examination of swallowing is frequently done by nursing staff or speech-language pathologists (**Figure 8-15**) and identifies between 42% and 80% of patients subsequently determined to aspirate on video fluoroscopy.[34,35] However, half of patients with aspiration have no symptoms at all (''silent aspirators''). The role of dysphagia in causing aspiration pneumonia is somewhat controversial, but oral feeding should not be attempted in patients with obvious clinical aspiration. Nutritional needs should be met through a small nasogastric tube until improvement occurs or a decision can be made about a more permanent feeding tube (usually a percutaneous endoscopic gastrostomy tube). Swallowing disorders following stroke usually improve fairly quickly, but if not, a modification in diet should be considered. For further detail, see the article



FIGURE 8-15 Speech-language pathologist performing bedside swallowing examination. A variety of consistencies are assessed, including thin liquids, pudding, and a cracker.

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Case 8-2

A 58-year-old right-handed man developed acute onset of severe aphasia and right hemiparesis while sitting at home one morning. He presented to the emergency department and received IV tissue plasminogen activator therapy within 2½ hours of stroke onset after unenhanced brain CT was negative. Initial National Institutes of Health Stroke Scale (NIHSS) score was 18. His history was notable for prior myocardial infarction and coronary artery bypass grafting, type 2 diabetes mellitus, hypertension, hyperlipidemia, and smoking. He was on low-dose aspirin therapy at the time of the stroke.

Follow-up imaging studies revealed a large left hemispheric (middle cerebral artery territory) ischemic stroke that was thought to be due to a severe (greater than 90%) proximal left internal carotid artery stenosis. His acute inpatient hospitalization was complicated by mild hypotension (requiring pressor support), distal right lower extremity calf deep vein thrombosis (DVT), and aspiration pneumonia. One week after admission, he was discharged to an inpatient neurorehabilitation unit with a moderate-severe mixed aphasia (expressive greater than receptive component), mild-moderate dysarthria and dysphagia, moderate-severe right upper extremity weakness, mild-moderate right lower extremity weakness, mild right-sided sensory loss, and modest postural instability (limited sitting and standing). He had no visual loss, neglect, or pain syndrome. NIHSS score was 12 and modified Rankin scale score was 4. He was discharged to the rehabilitation unit on low-dose aspirin and statin therapy plus low-molecular-weight heparin.

He underwent intensive multimodality inpatient neurorehabilitation, with gradual clinical improvement over several weeks. He experienced no recurrent TIA or stroke events. He did have moderate depression, which was treated with medication plus counseling. He was monitored for stroke-related complications, and he had no urinary tract infection, falls, or seizures. His pneumonia and DVT resolved without further interventions. His mean arterial pressures were maintained at 90 to 100, and his glucose determinations were less than 150. Volume status and daily intake and output were closely monitored. The patient had considerable subluxation of his right shoulder. Care was taken to support the shoulder in a wheelchair arm trough, and the arm was also supported during transfers and other activities. Nonetheless, he developed shoulder pain, which was treated with continued gentle range of motion and nonsteroidal anti-inflammatory agents. While he improved somewhat, the shoulder remained a problem at discharge, requiring outpatient follow-up. His speech improved significantly but remained moderately nonfluent with scattered paraphasic errors and neologisms. He had minimal dysphagia at rehabilitation discharge. His cognition was very good. His right upper extremity strength was 3-4/5, with reasonable grip strength. Right lower extremity strength was 4/5, with ability to stand and walk short distances with a quad cane. NIHSS score was 7 and modified Rankin scale score was 3 at rehabilitation discharge.

He underwent uncomplicated left carotid endarterectomy 6 weeks after stroke onset and 2 weeks after inpatient neurorehabilitation unit discharge. He continued to undergo outpatient physical, occupational, and speech therapy, with continued gradual neurologic recovery. He returned to work, with some job modifications, 4½ months after stroke onset. He remained on antiplatelet therapy for future stroke prevention. His various stroke and vascular risk factors (hypertension, diabetes, and hyperlipidemia) were all treated; he quit smoking; and he was referred for treatment of obstructive sleep apnea diagnosed during his inpatient neurorehabilitation unit stay. He was very active in the local outpatient stroke support group and promoted his success across the continuum of stroke care from acute stroke management through his stroke recovery period.

Comment. This case is an example of a relatively typical patient with moderate to severe stroke and highlights the importance of careful neurologic and medical management before, during, and after rehabilitation. A common problem is shoulder pain, which usually can be managed conservatively, as it was in this case. Generally, this resolves slowly over time. This case also emphasizes the importance of community reentry, especially for a relatively young patient. In this case, the patient was eventually able to return to work with some adaptations and became active in stroke-related community activities. Stroke recovery takes time and one should maintain optimism despite significant stroke deficits, especially in a younger patient.

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KEY POINT

■ Shoulder pain occurs in up to 80% of patients with stroke. Every effort should be made to protect the shoulder during transfers, positioning, and wheelchair seating.

''Treatment of Language, Motor Speech Impairments, and Dysphagia.''

Urinary incontinence is common following stroke, with an incidence ranging from 38% to 60% in the early recovery period.[36,37] Incontinence has been correlated with size of stroke, degree of neurologic impairment, presence of aphasia, presence of dementia, and low BI score. The most common cause of incontinence appears to be detrusor hyperreflexia with a coordinated sphincter, but a surprising number of patients have normal detrusor function and are incontinent simply because they cannot communicate the need to void.[38] Occasional patients have a hypotonic bladder with overflow incontinence. A careful urinary function profile should be created, listing the volume of fluid intake, frequency and volume of voiding, and postvoid residual urine measurements. For patients with low postvoid residual urines, a timed voiding program is the best approach. For patients with large residual urine volumes, intermittent catheterization may be indicated. Foley catheters should be removed except when they are needed to prevent skin breakdown, as they are a source of urinary tract infections. Fortunately, incontinence usually improves with time, but if not, it becomes an important practical issue that families must deal with as they decide whether or not to care for a patient at home.

Shoulder pain occurs in up to 80% of patients with stroke.[39,40] Often the onset is delayed and occurs either late in the rehabilitation program or is discovered at outpatient follow-up. The shoulder is a highly mobile joint that depends heavily on the rotator cuff muscles for stability, making it very vulnerable to injury, especially during the flaccid period just after stroke (**Figure 8-16**). When the shoulder is unstable, pain-sensitive structures in and about the shoulder are easily injured, resulting in a variety of painful conditions including subdeltoid bursitis, supraspinatus tendinitis, brachial plexopathy, and rotator cuff tears. Weakness of the shoulder joint also results in subluxation of the humeral head out of the glenoid fossa. By itself, this is not dangerous or painful, but it is a clear indication of severe rotator cuff weakness and susceptibility of the shoulder to injury. In this circumstance, care should be taken during range of motion of the shoulder, and every effort should be made to protect the shoulder during transfers, positioning, and wheelchair seating. Staff must avoid traction or torsion of the shoulder during daily activities. Management of painful shoulder depends heavily on prevention, but when pain already exists, even more careful attention to positioning, gentle range of motion, and analgesics are indicated. As many as 25% of patients with stroke develop a form of complex regional pain syndrome known as shoulder-hand syndrome, which presents as pain and edema of the hand, autonomic changes in the hand including discoloration, and significant shoulder pain. This syndrome may occur 1 to 2 months after the onset of stroke and is often seen at clinic follow-up. The problem is often self-limited, but analgesics, anti-inflammatory agents, electrical stimulation, careful and progressive range of motion, and, occasionally, a short course of oral corticosteroids may speed recovery. On rare occasions a stellate ganglion block is necessary.

Spasticity is the term often used to describe the constellation of symptoms associated with upper motor neuron syndrome, including increased muscle tone, muscle co-contraction, synergistic motor movements, mass spasms, and clonus. Spasticity is quite common after stroke, occurring in up to 65% of patients. It is more common in younger patients and patients with

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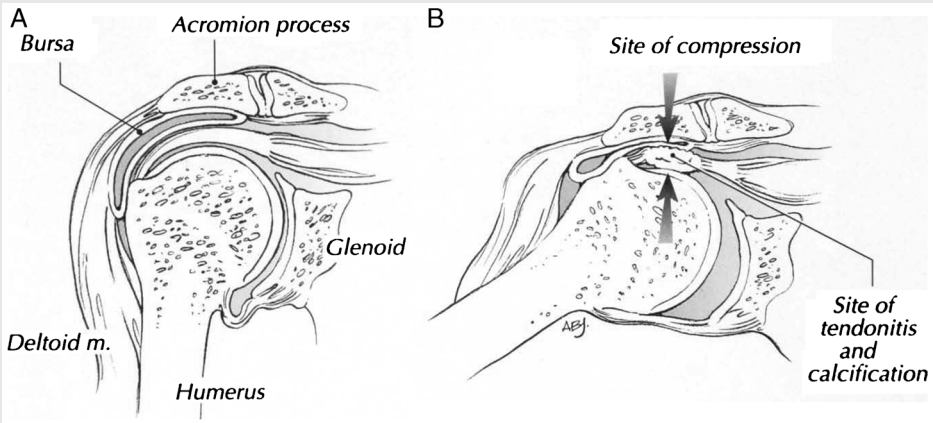


FIGURE 8-16 *A*, normal position of the head of the humerus in the glenoid fossa. Joint stability is highly dependent on the rotator cuff, including the deltoid and supraspinatus muscle pictured here. *B*, when the rotator cuff is weak, abnormal relationships exist between the humeral head and pain-sensitive structures in and about the shoulder. During passive abduction, compression of the subdeltoid bursa and supraspinatus tendon may occur.

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more severe weakness.[41] Spasticity is usually not debilitating, but in some cases it can result in unpleasant mass spasms, annoying clonus, and abnormal motor posturing such as excessive plantar flexion, foot inversion, and flexion of the elbow, wrist, or fingers. On occasion, spasticity may result in functional impairment. In these situations, a number of treatment options are available, including proper positioning, frequent stretching, and splinting. Oral medications are not usually helpful for poststroke spasticity. Drugs such as baclofen, benzodiazepines, and tizanidine often have sedative side effects and may have deleterious effects on motor recovery, so they should be used with caution. In many individuals, treatment with botulinum toxin is helpful, especially in cases of focal spasticity. Botulinum toxin has been shown to be effective and well tolerated. The major benefits are improved range of motion and prevention of contractures.[42] In some patients, botulinum toxin injections may improve specific activities, such as dressing, grooming, and positioning.

The risk of falls following stroke is a major concern. Almost 40% of patients with stroke experience at least one fall during rehabilitation, and injuries are reported in 22% of falls.[43,44] Falls are more frequent in patients with hemineglect, during transfers, in patients with cognitive impairment, and in patients receiving sedative medications. Falls at home or in the community may be prevented with proper training of the patient and caregiver and use of hand rails, grab bars, and adaptive equipment. A major consequence of falls is hip fracture, which usually occurs on the hemiparetic side and may occur months or years following stroke. This is partially due to bone loss associated with immobility. The use of biphosphonates may be considered.

POSTSTROKE DEPRESSION

Depression is common following a stroke, with prevalence ranging from 20% to 80% depending on the diagnostic tools used.[45] Traditionally, poststroke depression has been relatively

KEY POINTS

- Spasticity is usually not debilitating, but in some cases can result in unpleasant mass spasms, annoying clonus, and abnormal motor posturing such as excessive plantar flexion, foot inversion, and flexion of the elbow, wrist or fingers, which may result in functional impairment.
- The risk of falls following stroke is a major concern. A major consequence of falls is hip fracture.

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KEY POINT

- Patients with stroke who are depressed have increased mortality and greater cognitive impairments compared with patients who are not depressed. Good evidence also demonstrates that poststroke depression is associated with worse functional outcome.

underdiagnosed and undertreated, although this has improved in recent years. Patients with stroke who are depressed have increased mortality and greater cognitive impairments compared with patients who are not depressed.[46] Evidence also indicates that poststroke depression is associated with worse functional outcome and that depression can be effectively treated (**Case 8-3**). Early literature suggesting that poststroke depression was associated with left hemisphere lesions has come under scrutiny, and the association between depression and specific anatomic regions of the brain is now controversial. Diagnosis of depression is based on the traditional clinical symptoms of depression, including change in appetite

Case 8-3

A 76-year-old man was admitted for inpatient rehabilitation following hospitalization for an acute right cardioembolic middle cerebral artery infarct secondary to paroxysmal atrial fibrillation. His hospital course was prolonged and complicated by pneumonia, an acute myocardial infarct, and difficult-to-control hypertension. He had no personal or family history of depression or other psychiatric disorders. Prior to his stroke he had been actively involved in multiple social activities, was an avid hunter and golfer, and, per report of his wife, had ''amazing wit and an active mind.'' Following his stroke, which resulted in left hemiparesis, hemisensory loss, dysarthria, and dysphagia requiring placement of a percutaneous endoscopic gastrostomy tube, he became withdrawn, barely communicated, and had no interest in his environment. He frequently refused to participate in physical and occupational therapy, stating that he would prefer to stay in bed and that therapy would be futile as there was no hope for him. This resulted in constant arguments with the staff and his family and poor participation in the rehabilitation program.

On examination he was frail, underweight, poorly groomed, made poor eye contact, and spoke only in brief sentences when directly addressed. He had no spontaneous speech. He denied suicidal thoughts but felt hopeless, helpless, and without any energy. He was severely dysarthric with a central left facial palsy, left hemiparesis, and left-sided loss of sensation to all modalities. He was unable to ambulate but could stand with assistance. He was started on sertraline 25 mg/d with plans to increase to 50 mg/d after 1 week, with further incremental increases to an initial target dose of 100 mg/d, depending on response to treatment and tolerability. Further increases to a maximum of 200 mg/d could be considered if necessary.

Comment. Poststroke depression is common, occurring in approximately 30% of patients, with peak prevalence between 3 and 6 months after the stroke. It can be severely disabling and interferes with cognitive function, functional recovery, and long-term morbidity and mortality. Depression can be the result of psychosocial stress associated with the mourning of loss of function, imbalance in the cerebral neurotransmitter systems, or a combination thereof. Early diagnosis and treatment are crucial to prevent adverse outcome and improve recovery. Depression should be suspected in patients with apathy, fatigue, sleep disturbances, appetite changes, sadness, or suicidal thoughts. The association between depression and lesion location remains controversial. Treatment includes psychotherapy,

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Continued from page 562

counseling, and various antidepressants, considering their specific side-effect profiles. A number of agents have been shown to be effective in treating poststroke depression, including tricyclic and tetracyclic antidepressants, monoamine oxidase inhibitors, selective serotonin and norepinephrine reuptake inhibitors, and atypical antidepressants such as trazodone. Spontaneous remission typically occurs 1 to 2 years after stroke but chronic minor depressive symptoms can persist beyond this time period and should be treated.

and sleep, apathy, fatigue, and suicidal thoughts. Crying and overt sadness are the most reliable indicators of depression in stroke.[47] Patients with stroke who are not depressed may also experience fatigue and apathy, so at times the diagnosis can be difficult. Depression may also be confused with dysprosody, which frequently occurs in strokes involving the nondominant hemisphere. Most neurorehabilitation physicians have a low threshold for treating poststroke depression and often treat if the diagnosis is at all entertained. A number of antidepressants have been shown to be effective in treating poststroke depression, and choice of drug is often determined by the side-effect profile.

DISCHARGE PLANNING

Whether a patient can go home after a stroke depends on many factors, including age, severity of deficit, cognitive impairment, presence of incontinence, and comorbid medical conditions. However, the most important variable is often the family and social situation. A patient with significant residual disability is often able to return home if a competent caregiver is available. Before returning home, one of the most important tasks is close communication with the patient and caregiver. Both need to be educated about the patient's abilities and the tasks with which the patient will need assistance. Several ''hands-on'' training sessions with therapists may be necessary to ensure safe, energy-efficient techniques and to generate confidence in the patient and caregiver. Possible changes in the roles of the patient at home should be discussed (eg, meal preparation, financial management). Follow-up rehabilitation, either through home health or outpatient services, should be arranged, along with neurologic follow-up. The home may need to be adapted with equipment such as a commode, tub bench, cane, wheelchair, or other adaptive devices (**Table 8-2**). All of these issues should be systematically assessed days prior to discharge. At follow-up, attention should be given to the caregiver, as caregivers have a high risk of depression and ''burn out.'' Frequently the relationship between a spouse and patient may change, including role reversals and sexual dysfunction. Because stroke survivors are at risk for recurrent stroke, patients and families must be educated on secondary prevention, the signs and symptoms of stroke, and what to do if these occur. A study indicating that patients on an inpatient rehabilitation service had gaps in stroke knowledge and suboptimal personal health behaviors reinforces the importance of this education.[48]

COMMUNITY REENTRY

Driving is a very important goal, especially for younger patients. The decision to

KEY POINTS

- Whether a patient can go home after a stroke depends on many factors, including age, severity of deficit, cognitive impairment, presence of incontinence, and comorbid medical conditions. The most important variable is often the family and social situation.
- At follow-up, attention should be given to the caregiver, as caregivers have a high risk of depression and ''burn out.''

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KEY POINTS

- Safe driving requires attention, concentration, intact vision, and rapid response times. On-the-road testing with an experienced evaluator can predict safe driving with a high degree of accuracy.
- The factors most predictive of successful return to work include being a white collar worker, having preserved cognitive ability, and having preserved ability to walk.

TABLE 8-2 Home Adaption

Adaptation	Details
Ramps	1-inch grade for each 1 foot of length
Doors	2-inch clearance on each side for wheelchairs (30 inches to 36 inches wide)
	Handle adaptations (door knob covers or lever type)
Bathroom	5 feet to 6 feet wide for wheelchair turning
	Elevated toilet seat
	Grab bars
Other rooms	Rearrange furniture and rugs

drive should be made in consultation with the patient, family, and physician. Safe driving requires attention, concentration, intact vision, and rapid response times. Many patients have deficits in these areas following stroke, and driving should be strongly discouraged in these situations. This is also true for most patients with homonymous hemianopsia, visual neglect, and seizures. If the only deficit is hemiparesis, an adapted vehicle with steering wheel pegs and accelerator extensions may be designed. Between 30% and 61% of stroke survivors who drove before the stroke resume driving after the stroke.[49,50] On-the-road testing with an experienced evaluator can predict safe driving with a high degree of accuracy.

More than 25% of stroke survivors under the age of 65 are able to return to work. The factors most predictive of success include being a white collar worker, having preserved cognitive ability, and having preserved ability to walk. Vocational assessments, including neuropsychological testing, may be necessary before a final decision is made. Adequate workplace accessibility, knowledge about stroke and its consequences by both the employee and employer, and environmental accommodations may be other important aspects of a successful return to work. At times, a job coach may be helpful.

Leisure activities also contribute to quality of life and should be addressed by the rehabilitation team. Physical adaptations may be useful for some patients, such as adapted golf clubs or fishing equipment (**Figure 8-17**).

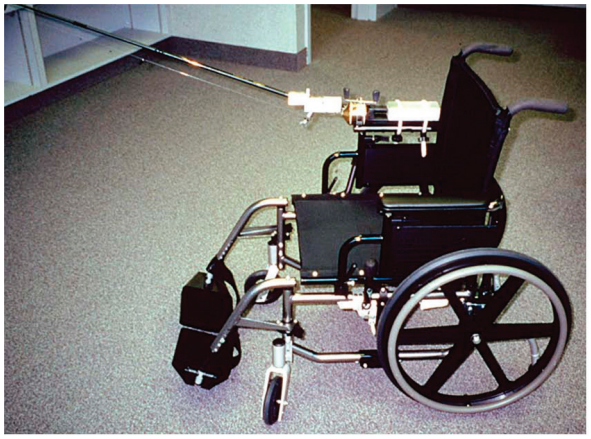


FIGURE 8-17 Wheelchair adapted to hold a fishing pole. Leisure adaptation for a patient with stroke with hemiparesis.

CONCLUSIONS

Successful stroke rehabilitation can make a tremendous impact on functional abilities and quality of life for stroke survivors and their families. Although a number of new therapy

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techniques are being developed and research in stroke rehabilitation is very active, much of day-to-day stroke rehabilitation is still based on techniques that have been helpful over many years. Much of this is based on adaptation to disability and involves careful attention to details as well as thorough training of the patient and caregiver. Neurologists can play a major role in stroke rehabilitation and with additional training can serve as the primary rehabilitation physician. For those neurologists who choose not to assume this role, basic knowledge of stroke rehabilitation is very helpful in understanding stroke recovery and helps the physician communicate with patients and families.

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