
Key Words: cerebrovascular accident • voluntary control • recovery

Rehabilitation outcome based on Brunnstrom recovery stages following comprehensive rehabilitation was examined for a sample of 98 inpatients with cerebrovascular accident and resulting hemiplegia or hemiparesis. Using admission and discharge dates retrieved from a computer-based patient information system, frequency distributions, cross-tabulations, and Spearman’s correlations were computed. Regardless of severity of paralysis, length of stay, and time of admission from onset, patients tended to improve at all levels of recovery stages. The stage of recovery at admission seemed to set the probable upper limit on how far patients were likely to progress. The strong positive correlations between recovery at admission and discharge on all measures for arm, hand, and leg recovery, with or without proprioception, seem to indicate that recovery in hemiplegia is a global phenomenon.

Patients with cerebrovascular accident (CVA) and resulting hemiplegia, when referred for comprehensive rehabilitation, tend to have longer onset-to-admission intervals, thereby portending less favorable outcomes (Feigenson, Gidow, & Greenberg, 1980; Gordon, Drench, Jarvis, Johnson, & Wright, 1978). During comprehensive rehabilitation, therapists not only assist patients with functional independence and compensatory skills but also spend a significant proportion of their time restoring effective sensory-motor control of the paralysed side (Brunnstrom, 1970; Shah & Corones, 1980; Stannington, 1980).

Loss of voluntary movement from damage to the central nervous system structures and hypertonicity from the release of intact structures are two of the most common factors influencing the return of voluntary control in hemiplegia. Therefore, a brief description of the problem of volition following hemiplegia is appropriate.

Following hemiplegia, loss of movement is selective and some movements are more affected than others. Movements that are least automatic, that have unlimited range and versatility, and that are precise and discrete suffer a greater loss than other types of movement. On the other hand, gross body movements such as standing, walking, fist clenching, and movements of trunk, back, and abdominal wall are less severely affected (Brodal, 1962; Brunnstrom, 1970; Evarts, 1974). This selective loss of movement in hemiplegia seems to indicate that there are two descending neural systems responsible for the organizational control of voluntary movement (DeSouza, Hewer, & Miller, 1980). Control of voluntary movements presents a further problem if inability to elaborate on the available information exists, thereby making discriminatory interpretation of sensory information difficult (Twitchell, 1954).

Moreover, following a CVA, there is immediate flaccidity in the paralyzed muscles. This state may last from a few hours to a few weeks depending on the site, type, and extent of lesion. Spasticity that follows the initial flaccidity is the result of enhancement of the autogenic excitation of the dynamic “1a” annulospiral receptors of the muscle spindle. This enhances the phasic element of the error detection function of the neuromuscular spindle with the extrafusal muscle. This manifests as a hypertonic, hyperreflexic state characterized
by increased resistance to passive movement. The "clasp knife" quality to stretch is the result of autogenic inhibition from the "1b" afferents (Burke, Andrews, & Ashby 1971; Carew, 1981; Hewer, 1979). As spasticity sets in after initial flaccidity, synergies also begin to appear (Brunnstrom, 1970; Shah & Corones, 1980; Twitchell, 1951). The gross nature of the synergies causes large muscle groups to act together, permitting these patterns to serve as a stepping stone for isolated and complex movement combinations. The control of voluntary movement may therefore be studied in terms of basic limb synergy patterns and deviations and in isolation from synergy patterns, or by reflexogenic techniques (Brunnstrom, 1970; Castigne, 1973; Fugl-Meyer, Jaasko, Lexman, Olsson, & Steglin, 1975).

For successful restoration of sensory-motor control, it is necessary to look beyond the diagnostic label of CVA; the neurological information from this label is generally insufficient for rehabilitation planning. The resulting degree of disability also is not synonymous with primary diagnosis, and there is no one-to-one correlation between such a diagnosis and disability (Landau, 1974). It is therefore important to evaluate the sensory-motor changes and the recovery stages in order to prevent secondary changes, accelerate the restoration, and measure the effectiveness of therapeutic intervention (Bard & Hirshberg, 1965; Brunnstrom, 1970; Newman, 1972; Twitchell, 1951).

PURPOSE OF THE STUDY

The purpose of this study was to examine specifically the rehabilitation outcome based on hemiplegic patients' ability to perform voluntary motion and their inability to utilize the available voluntary motion. Rehabilitation outcome was measured on both sets of variables using Brunnstrom recovery stages. Following efforts to restore sensory-motor status, the study examined first what level of improvement in sensory-motor function was possible; second, whether admission to the comprehensive rehabilitation stage set the proper upper limit on how far the patients were likely to progress; and third, whether the recovery phenomenon was selective or global in nature.

METHOD

The study sample comprised a total of 98 patients with a primary diagnosis of CVA and resulting hemiplegia or hemiparesis for whom the admission and discharge (Brunnstrom index) scores were available. All the patients were admitted for the first time at a rehabilitation and research training facility. Each patient received intensive occupational and physical therapy for at least two hours daily for five days a week. During their stay as inpatients, these patients also received other rehabilitation services considered appropriate by the team. At least 50% of the therapists' total time was spent in specific sensory-motor reeducation for the lower extremity, upper extremity exclusive of the hand, and the hand.

Data pertaining to the age, sex, neurological status, side of paralysis, time interval from the date of onset to the date of admission, and the Brunnstrom physical recovery stages of inpatients with CVA and resulting hemiplegia or hemiparesis of the right and left side of the body were accessed from the REHABIS (Harasymiw, Nosbich, & Stahl, 1978) data base in order to examine the performance status of these patients at the time of admission for comprehensive rehabilitation and at discharge. Voluntary movement is recorded in the data set in term of basic synergy stages. These recovery stages provide a framework within which it may be possible to determine whether a patient is a rehabilitation candidate. This framework also permits determination of realistic goals, structuring of appropriate intervention strategies, and establishment of a baseline for progress and subsequent discharge. The components of hemiplegia evaluation and the grading system used for analysis in this study are described in the following section.
**Recovery Stages**

The recovery stages exhibited by the patients in their involved extremities are recorded under (a) lower extremity, (b) upper extremity exclusive of the hand, and (c) the hand. For upper and lower extremities, the recovery stages are as follows:

1. The patient evidences flaccidity, with little or no resistance to passive motion and no initiation of voluntary movement.

2. Spasticity begins to develop, and initiation of synergies is possible on voluntary effort or an as associated reaction.

3. There is increased resistance due to spasticity, and limb synergies are performed voluntarily.

4. Spasticity is less evident than earlier, and movement combinations that deviate from synergies are possible.

5. There is minimal resistance from spasticity, and individual as well as complex movement combinations are possible independent of synergy.

6. Spasticity is difficult to demonstrate unless movements are performed with rapidity, and synergies do not interfere with performance.

For the hand, recovery stages are as follows:

1. Muscles are flaccid on the involved side.

2. The patient evidences minimal spasticity, and little or no active finger flexion is possible.

3. The patient is able to hold on to a handle placed in the hand but unable to release through voluntary finger extension. Reflex extension may be possible.

4. The patient is able to release by lateral thumb movement with minimal finger extension or through normal functional synergy. That is, he or she is able to grasp with the fingers while the wrist is extended and able to release the fingers while the wrist is flexed.

5. Voluntary mass extension of digits is possible, and the patient is able to control cylindrical and spherical grasp with limited functional use.

6. The patient demonstrates voluntary extension of fingers; lateral, palmar, and three-point prehension and individual finger movements are possible.

**Motor Control**

To grade functional use of available voluntary motion, the motor control patterns of trunk and upper and lower extremities are recorded as follows:
1. The patient requires maximal assistance to maintain position or is unable to use the body part for any purposeful activity.

2. The patient requires minimal assistance to maintain position or is able to use the involved extremity for holding, stabilizing, or weight bearing.

3. The patient is able to use involved segments for independent purposeful activity such as ambulation.

**Proprioception**

After the procedure for the actual test has been rehearsed, proprioception is tested for upper and lower extremities and further observed during ambulation. The findings are recorded as follows:

1. Proprioception is intact, and the patient demonstrates functional uses of the affected segments.

2. Proprioception is not intact; the patient is unaware of, unable to identify, or slow or inconsistent in responses to test procedures.

The interrater reliability for assigning the Brunnstrom recovery stages was determined using eighteen raters independently. Correlations between all sets of scores were calculated. The resulting correlation matrix for data showed very high interrater reliability coefficients ranging from 0.74 to 0.98 for ratings of lower extremity, upper extremity, and hand. The overall interrater reliability was determined by Kendall's coefficient of concordance (W) for each of the three variables, expressing the average agreement within a random five of the six sets of ratings on a scale from 0.00 to 1.00. The W values showed a high agreement (0.947 to 0.895). All were highly significant at the 0.1% level (Shah, 1980).

**RESULTS AND DISCUSSION**

Data analysis consisted of descriptive statistics, frequency distributions, and cross-tabulations of information on the REHABIS-selected CVA patients, as well as correlations. Correlations within and between measures at admission and discharge were calculated using Spearman's Rho (p) and standard significance criteria (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975).

Of the 98 patients admitted with a primary diagnosis of CYA, 32 had right and 26 had left total paralysis, and 22 had right and 18 had left partial paralysis. Their ages ranged from 45 to 84 years. The time interval between the date of onset to the date of admission for comprehensive rehabilitation ranged from 12 to 89 days.

**Recovery Stages**

Admission and discharge recovery stages of patients' upper extremity exclusive of hand, hand, and lower extremity are described in the sections that follow.

**Stages 1 and 2.** Patients admitted at stages 1 and 2 are essentially nonfunctional, although patients in stage 2 are able to initiate a pattern and have some traction response. Of the 36
individuals with a nonfunctional upper extremity, 13 progressed to develop control in synergies and 4 were able to move beyond synergies. Of the 53 patients with nonfunctional hand use, 10 went on to develop gross grasp, lateral prehension, and tenodesis release, and 2 exhibited voluntary extension of fingers. Of the 41 individuals with nonfunctional lower extremity, 8 went on to develop synergy control and 4 moved beyond synergies.

**Stage 3.** Stage 3 is a significant recovery stage because abnormal muscle tone starts to show signs of normalization and voluntary control begins to take a distinct form. Of the 26 patients with control in upper-extremity synergy, only 4 progressed to perform movements that deviated from synergy or developed individual and isolated joint control without interference of synergies. Of the 4 individuals admitted with the ability to grasp with mass flexion of fingers, 2 went on to develop control in lateral prehension and 1 developed control in palmar prehension and voluntary finger extension. Of the 15 individuals admitted with control in lower-extremity function, 8 progressed to perform independent movements of the hip, knee, and ankle. In other words, 15 % improved in upper-extremity, 75 % in hand, and 53 % in lower-extremity function.

**Stages 4 and 5.** Stages 4 and 5 demonstrate phases of movement deviating from synergy. Nineteen percent were able to perform movements of the upper extremity away from synergy and independent of synergies. Ten individuals increased function in upper extremity. In hand recovery, of those 23 patients with lateral prehension and mass extension, 11 (48 %) gained in hand function. Some patients progressed to palmar and three-point prehension and mass release of fingers; the remainder progressed to control all prehensile patterns and voluntary extension of fingers. Of the 26 individuals admitted with their lower extremities deviating or independent from synergies, 14 (54 %) showed improvement at discharge.

Approximately 17 % of the patients had already attained the final stage of the recovery process in each of the three areas. Consequently, these patients do not have a next stage of progress in terms of the classification used, although it seems likely that on discharge a number of these patients likewise were able to refuse their skills, perform movements with case, and increase their repertoire of movement combinations.

**Motor Control**

When the status of voluntary control was further examined (see Figure 1) in terms of patient ability to use the available motion for function, 57% of the individuals were nonfunctional in the use of their upper extremity at admission and 22 % were able to use the paralysed extremity for stabilizing or holding as an assist. Of the nonfunctional group, 13 individuals (32%) went on to use the upper extremity inclusive of the hand as an assist, whereas 6 (27%) with assistive function went on to independent use of the extremity.

Trunk stability and the ability to maintain an upright posture were the least affected functions. Only 5% were admitted with an inability to maintain an upright posture without
maximal assistance. These patients continued to remain dependent on discharge. However, 14 of the 35 individuals (40%) admitted with trunk stability advanced to be functionally independent.

Of the 21 individuals who were totally nonfunctional in their lower extremity, approximately one-half progressed to the point of being able to use the lower extremity as an assist during weight bearing and ambulation. Similarly, of the 42 patients admitted with lower-extremity capacity at an assistive level, 23 (55%) progressed to full weight bearing and independent ambulation.

Twenty-one individuals were admitted with functional arm use, 62 with functional trunk, and 37 with functional lower-extremity status. Although no higher measurement level issued, here again it is likely that some individuals progressed to refinement of their skills.

Proprioception

Voluntary motion seemed to improve regardless of the presence or absence of proprioception and regardless of the recovery stage at which the patient entered the rehabilitation program (see Figures 2 and 3). Figure 2 shows that patients who had proprioceptive loss also had gross motor involvement of their arm, leg, and trunk and were admitted at a lower recovery stage than other patients; their recovery progress seemed to be proportional to the severity of involvement. Patients who had intact proprioception on admission (Figure 3) had better motor control of their paralysed side and were admitted at a higher stage of recovery; subsequently, these patients progressed to a yet higher level of voluntary control on discharge.
Correlations between admission and discharge, at admission, and at discharge were calculated using Spearman's Rho ($p$) for lower extremity, upper extremity exclusive of hand, and hand recovery; for motor control in upper extremity inclusive of hand, lower extremity, and trunk; and for both proprioception in upper and lower extremity and gait (see Table 1). Correlations for all pairs of variables were positive and significant, ranging from 0.31 to 0.88 ($p<.001$). These observed relationships seem to indicate that recovery following hemiplegia is a global phenomenon. The high intercorrelations on arm recovery with or without proprioception on all measures seems to imply that if patients improve on one variable, they are likely to improve on an variables affecting the function of the paralysed side. Similarly, effectiveness of rehabilitation efforts seems to he dependent on the status of the patient on admission, and the admission status seems to determine the limits within which a patient is likely to progress during rehabilitation.

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Note: Significant at $p < .001$ level.

**CONCLUSIONS**

On the basis of this analysis of 98 patients with CVA and resulting complete or partial paralysis, and their Brunnstrom recovery status at admission and discharge, the following tentative conclusions seem warranted:
1. All patients are likely to progress. No patients regressed from their admission-level function in this study.

2. Patients seem to improve at all levels of recovery regardless of partial or complete paralysis, right- or left-side paralysis, length of stay, and time of admission to comprehensive rehabilitation from onset.

3. Admission recovery stage sets the probable limit on patient progress.

4. Excluding patients admitted at Brunnstrom recovery stage 6, it is unlikely that, following intensive occupational and physical therapy, more than 10% of the patients will progress up to stage 6 at the time of discharge.

5. The observed intercorrelations among variables seem to indicate that the recovery following hemiplegia is a global phenomenon.

These conclusions must be considered provisional until a much larger sample is studied than was used here and these findings are replicated in other comprehensive rehabilitation environments.
REFERENCES


