Predictors of Functional Outcome Following Stroke

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KEYWORDS

• Stroke • Motor function • Language recovery • Functional outcome prediction

KEY POINTS

- Motor function at baseline and age are the strongest clinical predictors of stroke recovery. Bedside examination, such as Medical Research Counsel testing, can provide the clinician with enough information to predict long-term recovery.
- Ambulation ability is a strong predictor of long-term independence. Ability to regain walking ability can be predicted by balance ability at onset.
- Arm and hand recovery can be predicted by motor function at onset, but actual use of hand in functional activities requires significant recovery of motor speed and manipulative skill.
- Language recovery can be predicted by language ability at stroke onset. A good ability to comprehend language and intact repetition predict better language outcome.
- Combining motor ability, neurophysiological measures such as preservation of motor-evoked potentials by transcranial magnetic stimulation, and imaging may provide useful predictive value if current available models can be validated in large patient cohorts.

INTRODUCTION

Accurate prediction of functional outcome in patients with stroke has the potential to enhance clinical care as well as improve the quality of stroke research. Prognostic models can facilitate education and counseling of patients and families, and streamline planning for rehabilitation and discharge. Specific predictors can help target treatment options to the patients who will most benefit, and avoid treatments in those who are unlikely to respond. Such models can improve research analysis when adjusting for baseline characteristics in study cohorts and comparing different randomized trials for meta-analysis.[1]

The use of formal prognostic models to predict functional outcome have not been used in clinical stroke rehabilitation because large representative cohorts have not been studied and existing models are not well validated.[2] Thus, prognosis has been limited to a handful of "clinical pearls" and the clinician's personal experience, with

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the help of existing literature. It is important to note that the literature on prognosis has provided some useful information on recovery of impairment and activity, but fewer data on participation. Additionally, there is a paucity of research on the impact of cognitive and perceptual dysfunction and recovery. Most of the available literature is composed of small cohort studies and systematic reviews. Although formalized and validated predictive models would be an improvement over current practice, there remains much value in the use of "rules of thumb" for prognosis of functional outcome. The purpose of this review was to attempt to list those rules of thumb based on existing prognostic models, current epidemiologic evidence, and my own experience as a stroke rehabilitation specialist.

PATTERNS OF RECOVERY FROM STROKE AND KEY MEASURES OF OUTCOME

Motor recovery has been extensively studied in stroke due to the availability of reliable and valid measures. The first rules of thumb were provided by Twitchell[3] in 1951 when he described the patterns of natural recovery from stroke. In observing a cohort of stroke survivors he concluded the following sequential processes of recovery:

- Initial loss of voluntary movement and reflexes
- Rapid restoration of reflexes proceeding to hyperreflexia
- Development of increased muscle tone
- First voluntary movements in shoulder and hip
- Appearance of further voluntary movement with flexor pattern in upper limb and extensor pattern in lower limb
- Both flexor and extensor movements appear in upper and lower limbs
- Spasticity is reduced as isolated joint and finger movements emerge

Twitchell[3] noted that patients can progress quite quickly through this recovery pattern or stop recovering at any given level depending on stroke severity. Signe Brunnstrom[4] used Twitchell's findings[3] to develop a scale of motor impairment after stroke.[5] Later, Axel Fugl-Meyer and colleagues[6] used Twitchell's principles[3] to design a more detailed scale of motor impairment using an elegant scoring system. The upper limb portion of the Fugl-Meyer assessment (FMA) is now considered a standard outcome measure in clinical stroke recovery research.

Although the lower limb portion of the FMA also has been used in stroke research, recent clinical trials have used walking speed as an ideal measure of lower limb recovery. Walking speed is associated with lower limb impairment, aerobic capacity, and functional ambulation.[7–10] Improvements in walking speed also correlate with improved overall ability, as measured by the Modified Rankin Scale (**Table 1**).[11]

Although it is a fairly insensitive measure of functional activity, the Modified Rankin Scale (MRS) is a standard measure of outcome in acute stroke research and has been used in studies on early prediction of outcome.[12] Along with ambulation, overall severity of motor function is related to MRS, with minimal motor impairment being associated with favorable outcome, typically defined as an MRS $\leq$2 (slight disability or better).[13] But it is important to recognize that a favorable outcome on the MRS is not strongly related to recovery of the affected arm and hand. Aphasia, on the other hand, is associated with greater dependence as measured by MRS.[14,15] This is not surprising, given that significant residual deficits in comprehension predict a lower probability of return home following acute rehabilitation and are associated with lower motor and cognitive scores on the Functional Independence Measure (FIM).[16,17]

Thus, severity of impairment after stroke is related to overall functional ability. Better motor recovery in the arm and leg, faster walking speed, and good language